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AC/323(SAS)TP/14

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NORTH ATLANTIC TREATY ORGANIZATION

RESEARCH AND TECHNOLOGY ORGANIZATION
BP 25, 7 RUE ANCELLE, F-92201 NEUILLY-SUR-SEINE CEDEX, FRANCE

RTO MEETING PROCEEDINGS 39

Approaches to the Implementation of Environment Pollution Prevention Technologies at Military Bases

(Approches de l'application des techniques de prévention de la pollution sur les bases militaires)

Papers presented at the Symposium of the RTO Studies, Analysis and Simulation Panel (SAS) held in Budapest, Hungary, 5-7 May 1999.

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The Research and Technology Organization (RTO) of NATO

RTO is the single focus in NATO for Defence Research and Technology activities. Its mission is to conduct and promote cooperative research and information exchange. The objective is to support the development and effective use of national defence research and technology and to meet the military needs of the Alliance, to maintain a technological lead, and to provide advice to NATO and national decision makers. The RTO performs its mission with the support of an extensive network of national experts. It also ensures effective coordination with other NATO bodies involved in R&T activities.

RTO reports both to the Military Committee of NATO and to the Conference of National Armament Directors. It comprises a Research and Technology Board (RTB) as the highest level of national representation and the Research and Technology Agency (RTA), a dedicated staff with its headquarters in Neuilly, near Paris, France. In order to facilitate contacts with the military users and other NATO activities, a small part of the RTA staff is located in NATO Headquarters in Brussels. The Brussels staff also coordinates RTO's cooperation with nations in Middle and Eastern Europe, to which RTO attaches particular importance especially as working together in the field of research is one of the more promising areas of initial cooperation.

The total spectrum of R&T activities is covered by 7 Panels, dealing with:

- SAS Studies, Analysis and Simulation
- SCI Systems Concepts and Integration
- SET Sensors and Electronics Technology
- IST Information Systems Technology
- AVT Applied Vehicle Technology
- HFM Human Factors and Medicine
- MSG Modelling and Simulation

These Panels are made up of national representatives as well as generally recognised 'world class' scientists. The Panels also provide a communication link to military users and other NATO bodies. RTO's scientific and technological work is carried out by Technical Teams, created for specific activities and with a specific duration. Such Technical Teams can organise workshops, symposia, field trials, lecture series and training courses. An important function of these Technical Teams is to ensure the continuity of the expert networks.

RTO builds upon earlier cooperation in defence research and technology as set-up under the Advisory Group for Aerospace Research and Development (AGARD) and the Defence Research Group (DRG). AGARD and the DRG share common roots in that they were both established at the initiative of Dr Theodore von Kármán, a leading aerospace scientist, who early on recognised the importance of scientific support for the Allied Armed Forces. RTO is capitalising on these common roots in order to provide the Alliance and the NATO nations with a strong scientific and technological basis that will guarantee a solid base for the future.

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Approaches to the Implementation of Environment Pollution Prevention Technologies at Military Bases

(RTO MP-39)

Executive Summary

A symposium was conducted in Budapest, Hungary, from 4-7 May, 1999 on the "Approaches to the Implementation of Environmental Pollution Prevention Technologies at Military Bases". Support for the Symposium was received from NATO (The Research and Technology Organization and the Committee on the Challenges to Modern Society (CCMS)) and from the United States Departments of Defense and Energy. The symposium was attended by 21 Nations from NATO and the Partnership for Peace. Some 35 Technical Papers and reports were presented.

The recently completed Long Term Scientific Study (LTSS/44): "Environmental Technologies for Application to NATO Military Assets and Bases" served as the foundation for this Symposium. That Study was conducted under the auspices of the previous Defence Research Group (DRG), Panel 1. The focus of that study was Pollution Prevention at NATO Bases and aboard NATO Ships. LTSS/44 was a US led study that included participation from Canada, France, Germany, Netherlands, Spain, and the United Kingdom.

Specific study areas included: Solvents and Volatile Organic Compounds (VOC); Petroleum, Oil and Lubricants (POL); Ozone Depleting Substances; Munitions; Organic and Inorganic Coatings; Pesticides and Ship Wastes.

LTSS/44 recommended specific technologies to reduce or eliminate some of the most common and troublesome contaminants at the source. That study also suggested several ways to facilitate and expedite technology transfer to the greatest extent possible and to reduce possible duplication of efforts across nations and generally expand international co-operation in such environmental efforts. The Symposium in Budapest served to expedite the dissemination of information regarding Pollution Prevention both inside and outside of the NATO framework.

The Symposium was Chaired by Dr. Joel E. Tumarkin, US, The Institute for Defense Analyses, who served earlier as Study Director for LTSS/44. Keynote addresses were presented by Dr. Keith Gardner, Deputy Assistant Secretary General for Science and Technology, NATO; Mr. Gary D. Vest, Principal Assistant Deputy Undersecretary of Defense for Environmental Security, US; Dr. Janos Borbely, Deputy State Secretary, Ministry of Environment, Hungary; Dr. Bela Hajos, Deputy Minister for Water, Ministry of Transport, Communication and Water Management, Hungary; and Lt. Col. Eva Matrai, Head, Section of Environment and Safety Techniques, Ministry of Defence, Hungary. A report was presented by Special Working Group 12 of the NATO Naval Armaments Group (NNAG) on the implementation of LTSS/44 recommendations into the Clean Ships program and on the current status of naval pollution prevention activities.

National reports were received from Estonia, Germany, Georgia, Latvia, and Lithuania which discussed the current status of environmental activity and pollution prevention activities in these countries. Germany presented materials related to the use of Environmental Impact Analysis for sound development techniques, and the US presented methods and ideas for the future use of Information Technologies to disseminate Pollution Prevention Technologies quickly and accurately. Papers were presented dealing with the ozone problem, aircraft emissions and the implementation of the Montreal and Kyoto Protocols (UK, Germany, and the US respectively). Several papers were presented dealing with munitions and unexploded ordnance (Germany, Latvia, Sweden, UK, and US). The Czech Republic, Kazakhstan, Moldova, and Poland, presented information on the implementation of pollution prevention programs in their nations. Norway presented a paper on the prevention of PCB contamination in sea sediments and several excellent papers from Germany, Norway, UK, and the US dealt with coatings and coating removal. Netherlands presented new information related to the storage and management of POLs and chemicals. The UK and the US brought new information on the management and elimination of VOCs in the military environment. Canada presented a paper on the integration of Pollution Prevention technologies in land management workshops and training. New sensor technologies were discussed by Germany and the US for the identification, tracking and isolation of contaminated wastes. The participants reaction to the symposium was excellent and the overall tenor and quality of information presented and received was deemed to be of outstanding value. There are no plans for a follow on activity at this time. It is suggested that the proceedings be forwarded to the NATO/NIAG working group on pollution prevention in the acquisition process.

Approches de l'application des techniques de prévention de la pollution sur les bases militaires

(RTO MP-39)

Synthèse

Un symposium consacré aux approches de l'application des techniques de prévention de la pollution sur les bases militaires s'est tenu à Budapest (Hongrie) du 4 au 7 mai 1999 avec le soutien de l'OTAN (Organisation pour la recherche et la technologie et Comité sur les défis de la société moderne (CDSM)) et des ministères de la défense et de l'énergie des Etats-Unis. Vingt et un pays alliés et partenaires ont participé à cette rencontre accueillie par les forces armées du pays hôte. Environ 35 rapports et communications techniques ont été présentés.

L'étude scientifique à long terme (LTSS/44) récemment achevée sur les techniques environnementales applicables aux moyens et bases militaires de l'OTAN a servi de point de départ à ce symposium. Elle a été menée sous les auspices de la Commission 1 de l'ancien Groupe sur la recherche pour la défense (GRD), rattaché à la Conférence des Directeurs nationaux des armements (CDNA). L'étude était consacrée à la prévention de la pollution sur les bases de l'OTAN et à bord des navires de l'OTAN. L'équipe chargée de l'étude, dirigée par les Etats-Unis, incluait des participants du Canada, de la France, de l'Allemagne, des Pays-Bas, de l'Espagne et du Royaume-Uni.

Les thèmes abordés ont été les suivants : solvants et composés organiques volatiles; produits pétroliers, huiles et lubrifiants (POL), substances appauvrissant la couche d'ozone; munitions; revêtements organiques et inorganiques; pesticides et déchets des navires.

La LTSS/44 a recommandé des techniques spécifiques visant à réduire ou éliminer à la source certains des contaminants les plus courants et les plus problématiques. Elle a aussi suggéré plusieurs moyens de faciliter et d'accélérer dans toute la mesure du possible le transfert de technologie et de réduire les éventuels doubles emplois entre pays ainsi que d'accroître de manière générale la coopération internationale en la matière. Le symposium de Budapest a permis de faire circuler plus rapidement les informations concernant la prévention de la pollution à la fois dans le cadre de l'OTAN et à l'extérieur.

Le symposium était présidé par M. Joel E. Tumarkin (Etats-Unis), de l'Institute for Defense Analyses, qui avait aussi dirigé la LTSS/44. Des exposés sur le thème principal ont été faits par M. Keith Gardner, Secrétaire général adjoint délégué de l'OTAN pour la science et la technologie, M. Gary D. Vest (Etats-Unis), Premier assistant au Sous-secrétaire adjoint à la défense, chargé de la sécurité liée à l'environnement, M. Janos Borbely, Vice-secrétaire d'Etat au Ministère hongrois de l'environnement, M. Bela Hajos, Vice-ministre pour les ressources en eau au Ministère hongrois des transports, de la communication et de la gestion de l'eau et le lieutenant-colonel Eva Matrai, Chef de la Section environnement et technologie de la sécurité au Ministère hongrois de la défense. Le Groupe de travail spécial n°12 du Groupe OTAN sur l'armement des forces navales (NNAG) a présenté un rapport sur la mise en oeuvre des recommandations de la LTSS/44 dans le cadre du programme relatif aux navires non polluants et sur les activités en cours dans le domaine de la prévention de la pollution par les navires.

L'Estonie, l'Allemagne, la Géorgie, la Lettonie et la Lituanie ont présenté des rapports nationaux faisant le point sur les activités relatives à l'environnement et à la prévention de la pollution dans ces pays. L'Allemagne a présenté des documents sur l'utilisation de l'étude d'impact sur l'environnemnent pour la mise en oeuvre de techniques de développement rationnel et les Etats-Unis ont exposé des méthodes et des idées concernant l'utilisation future des technologies de l'information pour la diffusion rapide et sans risque d'erreur des techniques de prévention de la pollution. Des communications ont été faites sur le problème de l'ozone, les émissions des aéronefs et l'application des protocoles de Montréal et de Kyoto (par le Royaume-Uni, l'Allemagne et les Etats-Unis respectivement), de même que sur les munitions et les munitions non explosées (l'Allemagne, la Lettonie, la Suède, le Royaume-Uni et les Etats-Unis). Des experts de la République tchèque, du Kazakhstan, de la Moldova et de la Pologne ont décrit la mise en oeuvre des programmes de prévention de la pollution dans leur pays. La Norvège a fait un exposé sur la prévention de la contamination des sédiments marins par les diphényles polychlorés (PCB). Les revêtements et leur élimination ont fait l'objet d'excellentes communications de l'Allemagne, de la Norvège, du Royaume-Uni et des Etats-Unis. Les Pays-Bas ont fait part d'informations récentes concernant le stockage et la gestion des POL et des produits chimiques. Le Royaume-Uni et les Etats-Unis ont fait de même à propos de la gestion et de l'élimination des composés organiques volatiles dans l'environnement militaire. Le Canada a fait un exposé sur l'intégration des techniques de prévention de la pollution dans les stages et la formation à la gestion des terres. Les nouvelles techniques d'identification, de suivi et de confinement des déchets contaminés à l'aide de capteurs ont été présentées par l'Allemagne et les Etats-Unis. La réaction des participants au symposium a été enthousiaste et globalement, les informations présentées et reçues ont été jugées d'un intérêt et d'une qualité exceptionnels. Aucune activité de suivi n'est prévue pour l'instant. Il est suggéré de transmettre les actes du symposium au Groupe de travail du NIAG de l'OTAN sur la prévention de la pollution dans le processus d'acquisition.

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† Paper not available at time of printing.

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SWG/12 Maritime Environmental Protection Strategy

by

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Introduction: NATO naval ships operating in the 21st century will be expected to meet increasingly stringent environmental regulations. Special Working Group 12 (SWG/12) has a comprehensive shipboard pollution abatement program under way that will enable ships of the 21st century to be environmentally sound. The goal is for ships to operate worldwide with minimal potential for regulatory constraints, no inappropriate dependence on shore facilities, and no unreasonable costs imposed by environmental regulations. The basic strategy is to: design and operate ships to minimize air emissions, waste generation, and optimize waste management, and, where required, develop shipboard systems that will destroy or appropriately treat the wastes generated on board. If wastes are unavoidable and cannot be destroyed or sufficiently treated so that overboard discharges are not considered environmentally significant, they must be retained on board for recycling or treatment ashore.

Although the ultimate solution for on-board destruction has not been achieved for any shipboard wastestream, the members of SWG/12 have made considerable progress toward developing on-board capabilities for managing, treating, or processing solid wastes, oily wastes, hazardous materials, and medical wastes. They are still seeking satisfactory interim or long-term solutions for treating blackwater and graywater, but they have identified technologies with potential to treat these wastes, and development programs are in hand. International cooperative efforts to achieve environmentally sound ships are under way among NATO navies to share information and technologies, and to save time and money.

Description of the problem and proposed approaches: During the last 15 years, several international regulations have been adopted that significantly affect NATO navies. The International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) contains several annexes of which some are in effect and some have yet to enter into force. Annexes in effect include Annex I which essentially eliminates all oily waste discharges at sea and Annex V which prohibits the discharge of plastics anywhere and the discharge of solid wastes (except food waste) into special ocean areas. Annexes yet to come into force include Annex IV which proposes to prohibit the discharge of untreated sewage (blackwater) within specific distances from special areas' shores and Annex VI which proposes to limit air emissions from ships. Proposed regulations include restrictions on the use of certain underwater hull coatings for protection from fouling marine growth and a protocol for managing ballast water to prevent introduction of non-indigenous species of marine life. The other significant international treaty of concern to military ships is the Montreal Protocol which eliminates production of certain ozone depleting substances (ODS) including chloro-flouro-carbons (CFCs) and Halons.

Sovereign nations have the right to determine which international regulations they will ratify regarding environmental requirements. Nations then determine the applicability of specific international regulations to their military ships through domestic legislation. The decision by a nation to apply the requirements of the MARPOL 73/78 and/or the Montreal Protocol to their military ships demands the development of new technologies, management procedures, and the

Paper presented at the RTO SAS Symposium on "Approaches to the Implementation of Environment Pollution Prevention Technologies at Military Bases", held in Budapest, Hungary, 5-7 May 1999, and published in RTO MP-39.

installation of equipment into densely packed ships. Complying with these regulations affects ship operations, endurance, manning, maintenance, and the quality of life on ships. Additional impacts on planning, programming, and budgeting are also incurred from the costs of compliance at sea and the costs of installation and use of shore-reception facilities.

In addition to international regulations, increasingly complex and stringent national environmental regulations are being legislated in many NATO nations as well as other nations around the world. The national regulations are concerned with controlling ship-waste effluents in territorial waters and affect the off-loading of all ships' waste in port. Military ships have sovereign immunity, however, when adopted by authorities as conditions of port entry, these regulations could challenge the ability of NATO navies to enter ports they previously visited without restrictions. Any mistake has the potential for financial, legal, and political repercussions as well as damage to the public image of visiting navy ships.

NATO navies need to take action to prevent pollution or control pollution. NATO navies need to identify, properly manage, and process all wastes generated on ships, all hazardous materials used on ships, and all discharges from ships. For each potential environmental pollutant or problem, one or more of the following three actions is essential: reduce the use of environmentally harmful chemicals; reduce the amount of waste generated on board; and increase the treatment, processing, or destruction of wastes on board. The first two actions generally are considered pollution prevention and the third, pollution control.

Eliminating the use of environmentally harmful chemicals, such as ozone-depleting substances, toxic antifoulant hull coatings, and other hazardous materials, may be the best approach for some potential problems. Reducing the amount of waste generated on board may be the preferred approach, in some cases, over on-board waste treatment. As examples, reducing the amount of plastics or unnecessary packaging and packing material taken aboard may be worthwhile to simplify shipboard solid and plastics waste management. Similarly, reducing the volume of liquid wastes generated on board (such as bilgewater) may simplify on-board treatment. For the wastes and hazardous materials that cannot be eliminated through pollution-prevention measures, NATO navies need to develop management practices, pollution-control strategies and technologies that are suitable for shipboard use and applicable to the wastestreams generated on ships. Incorporating these measures early in the ship-design process will optimize the effectiveness of pollution-prevention and pollution-control techniques and reduce consequent life cycle costs and manning impacts.

Conclusions: NATO ships operating in the 21st century will need to be designed from the keel up to be environmentally sound. Nations should cooperate to share technology and save time and money. Information exchange within NATO's Partnership for Peace program will greatly assist our pollution prevention efforts.

Maritime Environmental Protection Strategy

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Contents

- Situation
- Policy
- Principles
- Objectives
- Strategy
- Implementation
- Conclusions

Situation

International Regulations - Mid 1970's

- MARPOL 73/78 Places Discharge Restrictions on Ships
  - Annex I - Oil Pollution
- Article 3 Exemption for Public Vessels
  - Comply as Far as Reasonable and Practicable
    - Pump and Dump as Required
- Navies Begin Waste Disposal R&D Efforts

Situation (cont.)

Regulations Evolve - Mid 1980's

- Increasing Pressure to Preserve Quality of Life
- Nations Concerned with Beach Litter
- MARPOL Annex V on Solid Waste Enters into Force
  - Prohibit Discharge of Plastics Anywhere
  - No Discharge Special Areas
- National Laws Begin to Place Environmental Requirements on Navies

Situation (cont.)

Regulations Continue to Evolve - 1990's

- MARPOL Annex VI (Air Pollution)
- MARPOL Annex IV (Sewage)
- Proposed MARPOL Annex on Ballast Water and Invasive Species
- Proposed MARPOL Annex on Anti-Foulant Paints
- Coral Reefs
- Marine Mammals

Policy

- Provide Properly Equipped, Trained, and Ready Forces that Execute their Military Mission with Minimal Impact on the Environment
- Develop Management Procedures and Technical Capacity to Act in a Manner Consistent with MARPOL 73/78 Regulations as Far as Reasonable, Practicable, and Affordable

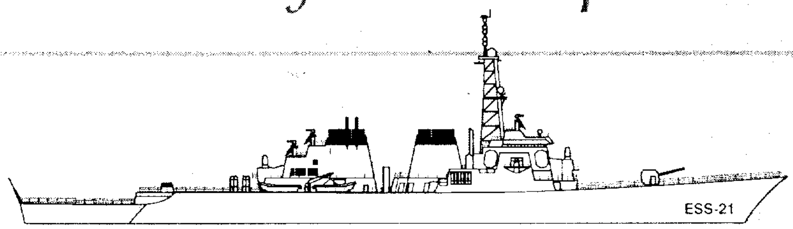
Principles

- Compliance
- Conservation
- Cleanup
- Pollution Prevention
- Training
- Environmental Leadership
- International Cooperation

Objectives

- Environmentally Sound Ships
  - Requirements Integrated into Ship Design
- Waste Management Systems
  - Ship
  - Shore
- Environmental Management Systems

Environmentally Sound Ship Attributes



- Fully Mission Capable
- Compliance with Environmental Regulations
- No Significant Adverse Environmental Impacts
- Minimum Use of Hazardous Materials
- Minimization of Air Emissions
- All Waste Streams Sufficiently Treated or Destroyed on Board Ship
- No Inappropriate Dependence on Shore Facilities for Waste Offload
- Minimal Logistical Costs for Waste Management

Methods to Achieve Environmentally Sound Ships

- Pollution Prevention
  - Reduce the Use of Environmentally Harmful Chemicals
  - Reduce the Amount of Waste Generated on Board
- Pollution Control
  - Increase the Treatment, Processing, or Destruction of Wastes on Board

Afloat Waste Reduction Efforts

- Alternative Packaging
  - Non-Plastic
- Hazardous Material Control and Management
  - Centralized Issue, Return, and Reuse
- Pollution Prevention Afloat
  - Alternative Technologies, Materials, and Processes

Typical Acquisition Strategy

- Market Survey
- Test and Evaluation
- Refine Requirements
- Marinize Equipment when Required
- Develop Equipment if Not Commercially Available

Early Years

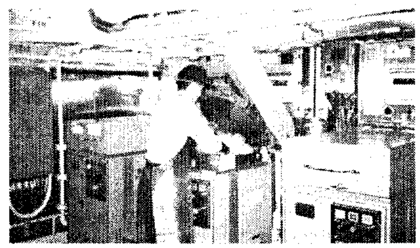
- Tested Commercial Compactors and Incinerators
  - Deficiencies Included Reliability, Maintainability, Safety, and Sanitation
  - Shipboard Incinerators Suffered Reliability Problems and Created Fire Hazards
- Tested Commercial Oil Water Separators and Oil Content Monitors
  - Deficiencies Included Performance, Reliability and High Logistic Support Costs
- Adopted Vision of Environmentally Sound Ships

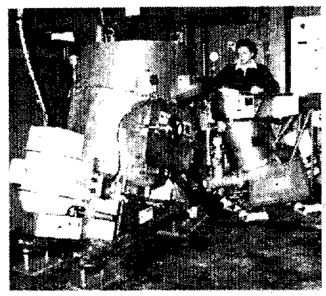
Navy Constraints

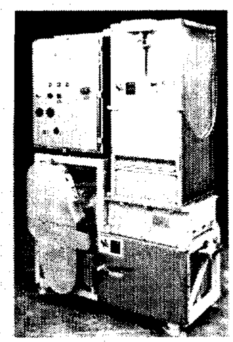
- Real World Requirements
  - World-Wide Operations
  - Long Mission Duration
  - Military Mission Effectiveness Can Not Be Compromised
- Real World Ships
  - Existing Fleet - What You See is What You Get
- Real World Budgets
  - Backfit is Expensive
    - Installation is 5 to 7 Times Procurement Cost

Typical Solid Waste Solutions

- Plastics Waste Processor (PWP) System
- Garbage Processing Machine
- Solid Waste Pulper
- Metal and Glass Shredder

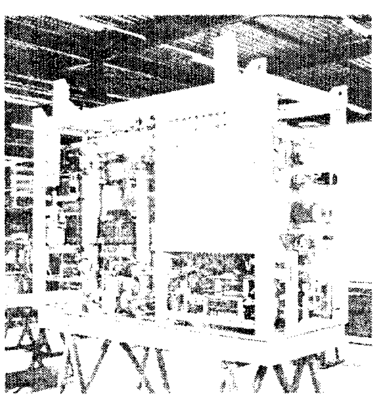


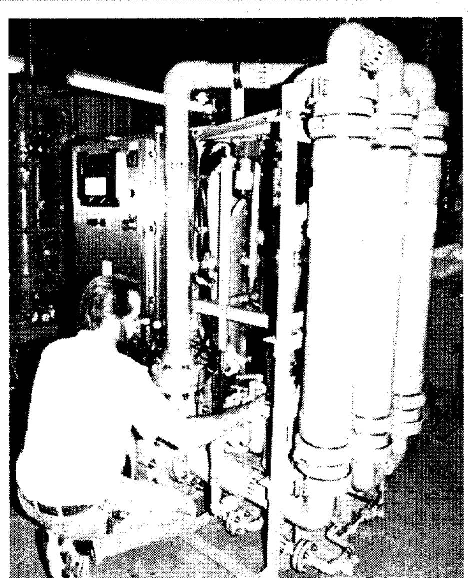




Typical Liquid Waste Solutions

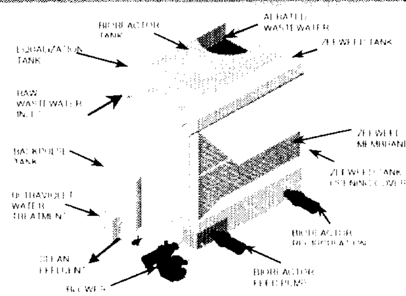
- Oil Filtering Equipment Employing Membrane Technology
  - Ultrafiltration or Microfiltration

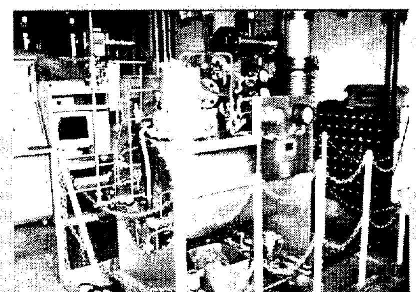




Typical Liquid Waste Solutions

- Blackwater
  - Biological/Membrane Treatment System
- Graywater
  - Membrane Concentration System
- Integrated Liquid Waste Discharge System
  - Advanced Vortex Incinerator





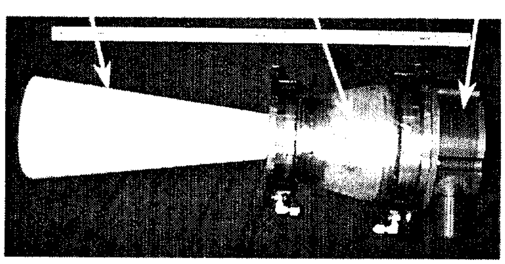
NATO Strategy for ESS-21

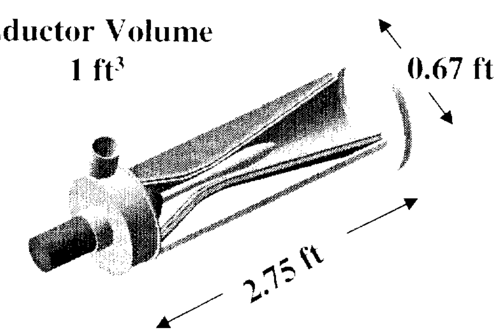
Current Wastes/ Emissions	Outlook for Treatment/Elimination: Year 2000	Outlook for Treatment/Elimination: Beyond 2000	
CFCs	New Refrigerants & Solvents	Alternative Cooling Technologies	
Halons	Some Continued Essential Use	Alternative Fire Suppressants	
Air Emissions	Little or No Change	Air Emissions Control	
Oily Wastes	OWS w/ OCMs	OWS/OCM w/ Effluent Polishing	
Sewage	Hold Where Required	Vacuum Collection	Destroy on Board
Graywater	Hold Where Required	Concentrate	
Trash	Shred to Sink or Hold		
Garbage	Hold or Pulp Before Discharge	Destroy on Board	
Plastics Waste	Compact, Sterilize, & Hold		
Hazardous Materials	Hold	Natural Antifoulants	
Antifoulants	Environmentally Sound Paints		

Requirements for Tomorrow!

- Thermal Destruction for Solid Waste
  - Advanced Incineration
  - Plasma Arc
- Thermal Destruction for Liquid Waste
  - Advanced Vortex Incineration
    - Blackwater, Graywater, and Oily Water Concentrates
- Integrated Thermal Destruction System
  - Capable of Meeting Solid and Liquid Waste Destruction Requirements
- Improved Management Systems for Short Duration Waste Holding
  - Small Ships Exceptionally Challenging

Plasma Fired Eductor Geometry

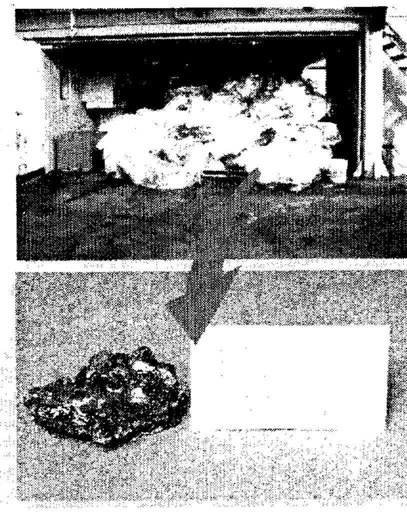




Advantages of PAWDS

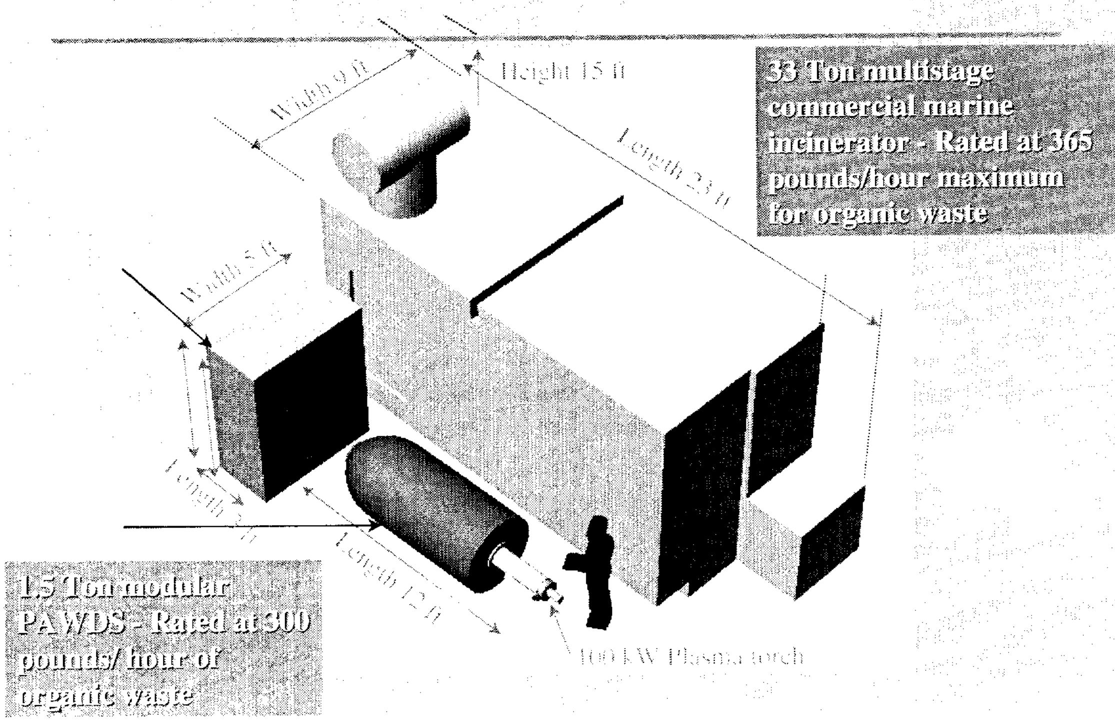
- Controlled thermal chemistry
- Complete gasification of organic waste and densification of inorganic waste
- Reduces volume of off-gas as much as 3:1 versus incineration
- Large ($\geq$ 75:1) waste volume reduction
- Little waste material (35 g/sec) in system at any instance
  - Rapid shut-down
- Eductor (cold-wall) design
  - Reduces system size & weight
  - Allows fast start-up
  - Provides robust components
- Allows integrated approach to shipboard waste management as recommended by Naval Studies Board

Ten days solid waste USNS Big Horn, T-AO 198



Slag formed from Navy Solid Waste

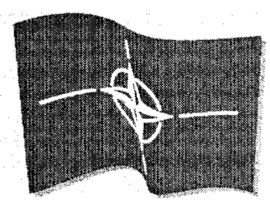
Comparison Between COTS and Plasma Arc Waste Destruction System (PAWDS)



Pollution Prevention Challenges

- Incorporating Pollution Prevention Throughout the Acquisition Process
  - Initial Design Through Production
  - Prime Contractors
    - Second Tier Suppliers
    - Third Tier Suppliers
- Operations and Maintenance
- Disposal

Implementation

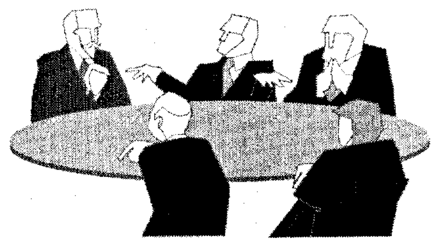


International Cooperation

- NIAG Special Working Group 12
- NATO Staff Target
- Joint AMEPP 4 / ANEP 59 with NG/6 on Functional Requirements for MEP
- US/UK Joint Feasibility Study
- Performance and Procurement Specifications being Incorporated into New Building Requirements

Industry Studies The Problem

- NIAG Pre-Feasibility Study on Environmentally Sound Ships
- Shipboard Thermal Waste Treatment Conference
- Shipboard Liquid Waste Treatment Conference
- Shipboard Solid Waste Treatment Conference



Defense Research Group Engaged

- Long Term Scientific Study (LTSS) 44 Recommendations
  - Include Environmental Considerations in Ship Design
    - AMEPP 4 / ANEP 59
  - Identify and Prioritize Technology Gaps
    - Technical Experts Meetings
  - Investigate Selected Technologies Through International Cooperation
    - Technical Experts Meetings
    - UK/US Feasibility Study

DRG LTSS/44 Recommendations (cont.)

- Important Technologies for Cooperation
  - Clean Thermal Destruction
    - PAWDS - US
  - High Performance Oil Filtering Equipment
    - Membrane Technology - GE/IL/UK/US
  - Aerated Wastewater Membrane Treatment System
    - Membrane Bio-Reactors - CA/GE/US
  - Effluent Quality Monitors
    - RDT&E - CA/US
- Examine Integrated Waste Treatment Systems
  - UK/US Feasibility Study

Continued Cooperation

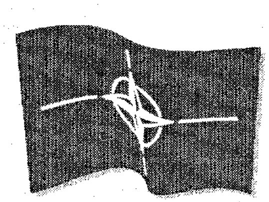
- Research and Technology Agency
- Committee for the Challenges of Modern Society
- Outreach To Cooperation Partners
  - MEP Symposia
    - Held in Bulgaria, The Netherlands, and Poland
  - SWG/12 Expert Teams
    - MARPOL and Oil Spill Teams Visits to Bulgaria and Romania

Controlling Our Destiny

- Working with National Delegations to IMO/MEPC to Write Technically Sound, Achievable and Affordable Rules
  - Participating in Revisions to MARPOL Annex I (Oil Pollution) and the Technical Requirements for Oil Filtering Equipment
- Working with National Legislation Process to Achieve Similar Goals

Opportunities for Standardization

- STANAG 7141 on Environmental Protection
- Joint/Combined Environmental Doctrine
- Navy Doctrine
- Environmental Annex to Operation Plans and Orders
- Environmental Planning
  - Oil Spill Contingency Plans
- Exercises



Conclusions

- SWG/12 is Extremely Valuable to NATO Navies
- NATO Nations are Working Together to Share Information and Technology
  - Including Outreach to Cooperation Partners
- DRG LTSS/44 Recommendations have been Incorporated into the SWG/12 Plan of Work
- Many Opportunities for NATO Standardization and Interoperability

AC/141(SWG/12)

Partners For Peace

Estonian Experiences in Application of Environmental Management

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Hereby I'm describing the development of two important environmental management tools - Environmental Impact Assessment and Environmental Auditing - in Estonia.

Environmental Impact Assessment

The first steps on elaboration of legislation in the field of environmental impact assessment (EIA) were taken promptly after our independence was regained in 1991 and eventually resulted in the governmental regulation No.314 of 13 November 1992 "On the EIA Procedure". This regulation establishes the main principles of EIA and the list of activities and projects which require EIA. A separate list included the objects which require EIA procedure at the national level. The general idea of the regulation does not differ from the principles established in the western countries. EIA should be considered as a necessary tool for decision making. While preparing environmental decisions EIA is an important stage providing good possibilities for making choices by decision makers.

It is important to mention that EIA is financed by the developer (subject of EIA). There are limited budgetary means from State Budget for such EIAs, the subject of which cannot be defined directly. This may be the case of projects of national or international significance, the impact of which reaches Estonia and the state is interested in assessing it.

At the same time, our regulation on EIA differs from those in the western countries. In the western countries organisation of EIA is a responsibility of the EIA subject and the state has only a role of supervision. In Estonia, the state is both organiser, coordinator as well as evaluator of the quality of an EIA study. This is due to the fact that taking into account ethical crises which resulted of recent economic decline, it has been an intention to prevent overassessment. It is a literal truth that 'The one who has the money orders the music'. Estonia has almost managed to overcome the above crisis and according to the draft Act on EIA and Environmental Audit, the state has only control functions. This principle is also supported by the requirement of licensed experts valid in Estonia. Licenses are issued by a License Commission under the Ministry of the Environment.

In Estonia EIA is carried out at two levels - national and regional. EIA at regional level is organised by County Environmental Departments. The list of EIA objects at national and regional level is given in a governmental regulation No.8 of 14 March 1994 "Methodological Guidelines for Implementing EIA in Estonia". In reality, the County Environmental Departments organising regional EIAs, are parts of governmental structure and therefore, talking about environmental protection structures of municipalities, only those of Tallinn and Narva could be mentioned. Initiation of a EIA process has been delegated to the regional level. Every new project or planned activity needs environmental authorisation. A municipality, as a decision maker, has to submit relevant materials to the county Environmental Department. The Department here decides on the necessity of EIA and in case EIA on national level is considered necessary, materials are passed to the Ministry of the Environment for organising such an EIA. In case of major objects, public tender procedures are announced to find expert companies and experts. Participation in such tender procedures requires above mentioned license. Although the time schedule for the EIA procedure established by governmental regulation is only one month, competent authorities have a possibility to prolong it on a well founded request of experts and without setting any time limits. The results of EIA are valid for two years. As for EIA is financed by the EIA subject and through a competent authority, the abovementioned procedure should encourage quick start of the planned business

Paper presented at the RTO SAS Symposium on "Approaches to the Implementation of Environment Pollution Prevention Technologies at Military Bases", held in Budapest, Hungary, 5-7 May 1999, and published in RTO MP-39.

scheme, because in two years time the EIA subject, which has financed one EIA study already will most probably face a need for financing a new one.

Public participation in the EIA process is a criterion for democracy. In the methodological guidelines of EIA it has been dealt with in detail. When a competent authority has decided to start an EIA procedure, it has to make this decision public and provide information on the planned activity or project. This enables to receive feedback from the public already during the preparatory stage and makes it possible to supplement the EIA programme. After the environmental impact statement (EIS) is drafted, it is the responsibility of competent authority to make it accessible for the public and interest groups for comments.

These comments are taken into account, analysed and added to the EIS. A decision maker, often a municipality, is now left with a hard burden of making the decision. It is not always that the reactions of the public and interest groups match with the results of environmental assessment. In the conditions of economic depression environmental issues are often not among the first priorities of an ordinary citizen. Decision makers have to make the decision taken public. Possible appeals are taken to the Court.

If there is a conflict with an EIS of regional level, it is possible to carry out a supplementary assessment on the national level. Until now, this has always brought about a satisfactory solution. Unfortunately, from the Soviet period, we have inherited a lack of traditions and experience in the field of public access to environmental information and public participation. Here we are facing a wide sphere of action to lessen the hesitation and apprehension of officials towards the public on one hand and mistrust of officials by the public on the other. The cases of site selection for Estonian Armed Forces Central Polygon and regional training areas are good examples of EIA studies on national level related with the Military Sector.

Unlike in most western countries, EIA in Estonia concerns not only new, planned objects (projects), but also objects undergoing renovation, liquidation or changes in ownership. The Act on Sustainable Development passed by the Riigikogu (the Estonian Parliament) on 22 February 1995, defines EIA and constitutes that implementation of EIA is regulated by law. The aforesaid leads the national regulation of EIA to a new qualitative level.
Drafting of a new law on EIA has already been completed. As it has also been decided in principle to accede to the Espoo Convention on Environmental Impact Assessment in Transboundary Context, the new law is in compliance with it. Estonia has switched into the process for preparation of the accession to the above international Convention conducted by the UN Economic Commission for Europe. Taking also into account Estonia's approximation phase with EU legislation, EC directives on EIA are considered as well.

Efficiency of introduction and implementation of environmental measures which to a lesser or bigger extent influence economic activities, depends greatly on the attitude of economic circles towards these issues. In addition to prime costs, the implementation of EIA system as well as other systems of environmental management includes economic benefits in a long term perspective. However, this only in case the state continues to support the principles of sustainable development via the use of economic instruments.

We have to be sufficiently wise and help the developers to see the future interests of investments made into EIA. It makes a big difference whether the bank financing a business project requires, among other loan documents an EIS simply out of its law obedience or real concern about the status of its loan project - has the borrower fulfilled all environmental requirements or neglected them, and would, in some years, have to compensate the damage caused by unforeseen environmental impact?

Introducing EIA and ensuring its quality, the role of databases is of notable importance. In Estonia, we have worked out and are continuously updating databases on experts conducting EIA which are accessible for all County Environmental Departments. A database on EIA studies linked to the database on experts is in final stage already. As within the preparation process for accession to the Espoo Convention, a database on EIA studies in Transboundary context is elaborated, we have an additional opportunity to use international experience on conducting our national EIAs.

Concerning EIA, it is necessary to understand, that environmental impact assessment is not decision making itself. It is an important stage helping the decision maker to prepare an environmentally sound decision. It depends entirely on the conscience and responsibility of the decision maker whether or not and to what extent he takes into account the EIS.

Environmental Auditing

Whereas the environmental impact assessment procedure is aiming at assessing the impacts associated with proposed new activities and the assessment is primarily focusing on forecasting of potential impacts, environmental auditing, on the other hand is the assessment of impacts of an existing, operating activity on the environment. Thus, environmental auditing can be regarded as a post-project analysis and follow-up of EIA and its quality. The environmental auditing provides the owner of the company a possibility to evaluate the current environmental situation and resource usage in the company and on sites, what is good, what could and should be improved, and where the potential risks are, as well as how to optimise the life-cycle of products from raw materials up to waste generation and management. It all provides the company preconditions, how to minimise or prevent costs on fees and pollution charges and save on materials and energy through developing an effective management system.

There are many definitions to describe environmental auditing. I would give one of them here: "Environmental auditing is a systematic, documented and objective process of gathering and evaluation of data, which aims at determining the compliance of audit scope with audit objective and audit criteria, and the delivering of the results to the audit client".

The role of environmental auditing as a part of general management system is described in many international and European standards: EN ISO 14001 "Environmental management systems - specification with guidance for use" and EN ISO 14004 " Environmental management systems - general guidelines on principles, systems and supporting techniques". Also there are other important international and European standards, which regulate environmental auditing. These are EN ISO 14010 "Guidelines for environmental auditing - general principles of environmental auditing", EN ISO 14011/1 "Guidelines for environmental auditing - auditing procedures, - Part I: Auditing of environmental management systems", and EN ISO 14012 " Guidelines for environmental auditing - qualification criteria of environmental auditors".

The process of introducing all the listed above standards to Estonia is coming to the final phase. The audit scope may vary to a great extent depending on the client's intentions. The audit types may comprise a site audit (potentially interesting to landowners, parties in privatisation process as well as to real estate companies), compliance audit (compliance of the operation of the company with environmental legislation, due diligence audit (clarifying the responsibility for environmental pollution between parties in the change of ownership of the company, privation) and corporate environmental management's system audit. The last type of audit is also regulated by EC regulation No183/93 or so-called "EMAS regulation". All above mentioned types are relevant to the Military Sector as well.

We are approaching the final stage of introducing and application of environmental auditing in Estonia, which has mainly been possible thanks to substantial foreign assistance. Estonia has been assisted by the Norwegian Government, Danish Government via UNDP and the European Union via LIFE programme.

35 people have successfully completed the training programme, 15 of them have gained the lead auditor's experience. 36 training audits in the Estonian largest infrastructure enterprises (e.g. rail, ports, power and heating plants), chemical enterprises and companies of chemical food manufacturing and in two prisons) were conducted under the guidance of Norwegian, British and Danish auditing companies of international reputation.

We have also organised workshops where the opportunities of audits and resulting potential benefits have been introduced to representatives of different sectors (government officials, businessmen, investors as potential clients).

The legal framework for environmental auditing is developed in the draft bill of Act on EIA and environmental auditing. Also an auditing guidelines targeted to auditors, audit clients and auditees is being prepared as a part of the project.

However, there is no EU legislation on environmental auditing, Estonian corresponding Act would follow the principles of EMAS (Management and Auditing Scheme) regulation.

As a principle, environmental auditing is a voluntary activity and does not require legislative procedures. Apart from that, in certain cases a need or interest may occur to apply an audit, in privatisation process in particular or if the state purchases real estate (in case of due diligence audit or compliance audit), or in cases where a company systematically violates environmental prescriptions (compliance audit). Environmental auditing may become a mandatory process also if a company of high environmental risk is concerned, as a follow-up of the EIA.

Further to that, the question of the qualification requirements of environmental auditors arises. The draft bill provides the base for these criteria.

In the relationship with audit client and auditees, auditors should follow the confidentiality principle, which means that an auditor operates similar to a family doctor or a lawyer , who would not share the information to third persons. The problem arises, if an auditor becomes aware of situations, which may impose a threat to human health or the environment, and informs the client about it, but the latter does not react on that correspondingly.

In order to introduce the environmental auditing successfully, the awareness of auditee and client of the opportunities of the new environmental management tool is of great importance.

While the information gathered during an audit is valued by banks, insurance companies and real estate companies as source of assessment for loan risks, insurance risks or liability, then it could also become in the focus of Estonian counterparts. It may well interest both parties - bank and borrower, real estate agency and mortgagor.

Similarly may enterprises and environmental authorities benefit from auditing results, where the enterprises via proving the status of environmental issues to the latter also acquire valuable information on the sustainable management of the enterprise and authorities receive useful information for the environmental decision making (e.g. issuance of environmental permits) in return.

The benefits of introducing and implementation of EIA and Environmental Auditing in Estonian Armed Forces could be described shortly as:
-ensuring ongoing compliance with environmental legislation;
- limitation of liability;
-better and more sustainable resource management;
-improved relation with the public and environmental authorities;
-lowering and managing environmental risks and health and safety risks for the staff;
-increasing effectiveness of environmental education and training together with increasing environmental awareness of all level of personnel;
-creating additional capacity for reaching the NATO standards;
-long term saving of financial and other resources.

The speed of general society development and setting of priorities determines the scope and timing of introduction and implementation environmental management tools in our Military Sector as well. In principle, it is the process via forecasting or identification of already existing environmental problems, assessment of their current status, developing towards production and management control and continual improvement.

Environmental Impact Analysis as a Tool for Environmentally sound Development

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1 Introduction

All human activities cause environmental burdens. The question is whether these burdens are necessary and how great they will be.

The amount of environmental impact of a system -- either a civil or military one -- is defined in the development process. So it is important to take environmental issues into account as early as possible in this process.

Environmental issues must be an integral part of every development.
The environmental guideline in the procurement process is to develop and to obtain defence materiel that fulfils the military and technical requirements and pollutes the environment as little as possible.
For military items, the main emphasis is on operation and disposal during peacetime.

The environmental issues during the procurement process can be summarised in the following goals:

- Saving of energy,
- preservation of resources,
- prevention and disposability of waste,
- reduction of emissions,
- replacement of hazardous and radioactive materials,
- preservation of bodies of water,
- prevention of soil contamination.

These aspects which are very broad will be taken into account during the whole process.

Throughout the whole process environmental considerations should be on par with other considerations, such as effectiveness, quality, military life-cycle costs, and terms of delivery.

2 The Environmental Impact Analysis (EIA) as a Management Tool

During the development of a complex system it is necessary to find a good way to include all environmental aspects. The EIA is a management tool that encompasses all the relevant issues.

This analysis has the following purposes:

- to pinpoint the essential **burdens on the environment** which will be associated with the defence materiel being developed,
- to identify the pertinent **legal, administrative or technical provisions** concerning the acquisition program,
- to furnish proof that the identified burdens meet these provisions,
- to examine possibilities of reducing environmental impacts even below allowed legal limits,
- to bring about necessary decisions by supervisory authorities (approvals, permits)
- to point out that the chosen approach is environmentally compatible compared to alternative solutions,

Paper presented at the RTO SAS Symposium on "Approaches to the Implementation of Environment Pollution Prevention Technologies at Military Bases", held in Budapest, Hungary, 5-7 May 1999, and published in RTO MP-39.

- to point out which measures have already been taken to achieve environmental compatibility,
- to point out **measures** which **remain** to been taken to establish environmental compatibility as well as the corresponding time schedules,
- to point out remaining risks,
- to point out additional measures which have to be taken by someone else (e.g. infrastructural measures or matters of training) and preconditions or necessary constraints for the future operation of the defence materiel which have to be taken into account by the user,
- documentation of relevant information about the materiel.

Subjects of the environmental-impact-analysis with respect to defence materiel's life-cycles are:

– development:	+	design, technical tests, service tests
– procurement:	+	production
– in-service phase:	+	operation, training,
	+	storage, transport
	+	maintenance, preservation
– disposal process:	+	further utilisation, recycling, disposal

The main emphasis has to be put on operation and disposal during peace time

Some of the EIA purposes will be discussed in more detail in the following paragraphs.

2.1 Identification of essential environmental burdens

In a complex system like a main battle tank there are a lot of environmental impacts. In this case, the task of the EIA is to identify the essential ones. This step has to be done very early, so that during the following steps the focus can be set in the right direction. It is not very useful to invest a lot of work in the use of a lithium battery, when in the same munitions toxic gases will be produced during the launching process.

2.2 Legal requirements

In our communities, the military must obey the law. In Germany, the armed forces also must adhere to environmental legislation. Exemptions for military reasons are defined in the laws if necessary. The ability to use these exemptions is very restricted.

So it is important to find out which legislation can be relevant for the materiel in its in-service phase. Especially when systems are used in ecologically sensitive areas, there may be a lot of specific requirements pertaining to the system's construction. If these regulations are not identified and the materiel is not designed to meet these requirements, it may cause restrictions in use or more severe results. In the best case, it is possible to refit the materiel but this will lead to very high additional costs and efforts.

The EIA has the purpose of identifying the relevant regulations and also documenting the observance of legal, administrative or technical provisions.

2.3 Environmental data

For the environmentally sound use of materiel in the in-service phase, some data and information are essential. The EIA has the task of producing and collecting them during development. There are two large classes of data that are important. The first group is data about hazardous and environmentally relevant items. The second is information about the disposal of spare parts or the whole system. All this information should be integrated into the logistic information, because the processes with greatest environmental relevance during the in-service phase are logistical ones.

2.3.1 Data about hazardous and environmentally relevant items

Military systems are in service for a long time. In this period legislation often changes to become more restrictive. For example, 20 years ago asbestos was a favorite materiel for a variety of applications. Today it is forbidden in many countries. If during development no documentation is prepared which deals with this problem, it will cost a lot of money, time and energy to get this information. We have some experience in finding substitutes for now forbidden or banned materiel. The greatest problem was identifying the relevant parts. With good documentation, this job will be easier. It is the responsibility of the project manager to find the right solution: having reviewed an extensive list of all used materiel, he must make a concerted effort to identify relevant materiel. A good way to collect all relevant Information is a "List of hazardous and environmental relevant Items" which includes all information about HazMat, LASER, radioactive items, etc. This list should be a document or better database, which will help the management during the use of the materiel to check the system.

2.3.2 Concept of disposal

At the end of every life cycle the materiel has to be disposed. "Disposal" includes all methods to get rid of something, such as recycling, reuse, dismantling or deposition at a landfill. During development, it is necessary to check what can be done with the system components at the end of the life cycle. So it would be useful to prepare a "Concept for disposal" which includes the information about:

- waste being obtained during the in-service phase or, in case of disposal, of the defence materiel being developed,
- the classification of this waste with respect to the law pertaining to possible disposal methods,
- how these methods correspond to legislation,
- preconditions for handling the materiel over to anyone else (e.g. bans on putting it into the market).

This Concept has to be updated during the in-service phase from time to time, because legislation, especially in the area of waste management, changes.

2.4 Environmental issues in the documentation

At the end of the development, a lot of information including certificates, restrictions and special advice for an environmentally sound use of the materiel will hopefully be collected and available. All this information must be not only available to the management (perhaps as "fileware" which means as paper in the file cabinet). It is important to bring this information to the customer or user. Therefore all relevant hints or restrictions or measures must be integrated into the user manuals.

3 The EIA as tool to estimate and minimize the Life Cycle cost

In most management systems for the development of materiel, life cycle costs have a great weight, because the materiel will be used for a long period. For example in the life cycle of a washing machine, which is scheduled by industry for 10 years, 90% of the complete used energy is used during the "in-service phase".

The life cycle cost analysis normally deals with costs, which can be identified easily, or which are clear to everyone. In the environmental sector, there a lot of "hidden" costs, which cannot be directly assigned to a process. These costs are caused by enforced actions especially when HazMat is in the loop.

For Example: For the handling of HazMat, many regulations must be followed. The more hazardous the materiel is, the higher the regulations and therefore the expenditure will be. Some of these costs are

- Transport (HazMat transport is more difficult to manage, or it is permitted to transport only small quantities)
- Storage (for HazMat special storage requirements are given)
- Infrastructure (You need specially designed and built stores or workshops)
- Use and handling (for HazMat there are sometimes special requirements for documentation, who had contact with the HazMat, and so on. Perhaps the use is connected with a special license)
- Disposal (HazMat is expensive to dispose of)

These are only the foreseeable costs, which cannot be assigned exclusively to one defined process. But there are a lot costs that are not included here, and will not be identified on the first look such as:

- Higher rate of illness
- More medical check ups
- More control, surveillance and checks (also from other government agencies)
- More protection requirements (perhaps special protection clothing)
- More technical expenditure (such as special filter equipment, which will also produce costs in maintenance such as changing the filter, and disposing of the used filters as HazMat)
- More training efforts to fulfil the requirements.

In the United States (ARDEC Industrial Ecological Center Picatinny Arsenal New Jersey) a lot of basic work in the area of environmental cost analysis has been done.

During development, a comparison of alternatives should include these considerations, in addition to the purely environmental ones like emissions, etc. A supposed cheap solution can, in the end, become a very expensive one.

Comparison of alternatives is an important task of the EIA. For this mission it is not necessary to create a full Eco balance. This will be very difficult and is, in my opinion sometimes a "religious" question, especially when different environmental impacts must be compared or balanced. For example: Is it environmentally more friendly to cut woods somewhere to produce a natural-based thinner, or it is better to produce a thinner in a chemical plant? It seems to be a good approach to make a kind of "gate to grave" analysis, because these life cycle parts can be influenced by the developer.

To analyze the environmental impacts during the life cycle, computer programs are available on the market. These are Eco balance software programs. Some of them also include financial aspects, so it is possible to compare the environmental benefit to other possible costs during the system's life time. It also will show the cost drivers in the process. There is

only one handicap: the costs for the relevant components such as work, infrastructure etc. must be available. In official services, it is often very difficult to find out these data.

4 The EIA as a Software Tool

The EIA is a process with changing objectives during the development of a product. It seems to me, based on my experience, that a unique software tool to produce an EIA is not useful. However Software to assist the individual tasks is necessary.

A very important part of the "software environment" is a database for legislation. In the environmental sector, the volume of legislation is tremendous, especially when all regulations and technical specifications are included. (In Germany we have over 800 laws in the environmental sector alone.) Such software is normally available on the market.

Also, information about Hazardous Materiel is needed.

It is also useful to have software to prepare a life cycle cost analysis, as mentioned earlier. Such software is also available on the market.

To document environmentally relevant data and information, a database should be used. The design of this database depends on the system which is used to assist the logistic processes in the armed services. In Germany, we are creating a Database which focuses on the Project with interfaces to central information systems, including NATO cataloguing programs. The database will be a small Microsoft Access solution.

5 Conclusions

The EIA can be the central management tool for environmental considerations during the development of a new system. The EIA changes its focus during the whole process from a more qualitative objective in the beginning of the development to one of documentation of the remaining environmental impacts and data with steps to optimize the environmental impacts in-between. It is also a tool to estimate the environmental life cycle including the cost aspects, and therefore it will help determine the right decisions.

In the end, to paraphrase an old Indian proverb:

We have not inherited the earth from our ancestors; we have borrowed it from our children.

Cadmium, A Health Hazard Surface Treatment

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1 Introduction

The use of materials involving health risks represents a health risk in general and an environmental risk.

In some instances restrictions have been imposed on the marketing of materials that are injurious to health and on the use of specific hazardous materials and their processing. This is the case with asbestos, PCB/PCT, cadmium and cadmium alloys etc. These restrictions are published within the European Union in what are known as EEC Directives (EEC 76/769). If individual countries within the European Union wish to adopt these restrictions, these restrictions have to be implemented by passing legislation at a national level.

Implementation of this EEC Directive under German law resulted in the Chemicals Prohibitory Regulation (Chemikalien-Verbotsverordnung).

Thus, for example, cadmium and its alloys must not be marketed pursuant to this EEC Directive and the Chemicals Prohibitory Regulation. However, the present legal situation does allow a few exceptions.

One exception, for example, is aerospace, where cadmium may still brought into circulation and used.

This affects the military sector to an equal extent. Cadmium is still used today for surface treatment (corrosion protection) in a large number of weapon systems.

Hazards to humans and the environment arise from cadmium in the following specific processes:

- manufacturing (electroplating processes)
- maintenance and repair jobs and
- disposal, of course.

2 Cadmium-Related Health Risks

What then are the actual risks caused by cadmium?

I would like to deal briefly with this question and then explain those characteristics of cadmium which are injurious to health in greater detail:

Cadmium is a chemical element and is a silvery white, shiny, soft and ductile metal.

In view of its good characteristics for corrosion protection, cadmium is frequently used as a treatment for metal surfaces.

An object containing cadmium is not especially injurious to health on its own. No risk is involved simply by touching it.

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A potential hazard occurs, however, when such objects are processed and high temperatures are generated.

The reacting capacity of cadmium with oxygen at high temperatures results in cadmium oxide.

Cadmium oxide is formed during grinding, filing and welding operations, for example.

The fumes of cadmium oxide get into the human organism upon inhaling.

One aspect which should not be ignored is the cadmium-plating process and also the waste disposal of items containing cadmium. This is the way into the environment.

Our health may be influenced by an accumulation of cadmium and cadmium alloys in our body.

Thus cadmium poisoning results in:

- impairment of liver and kidneys (in view of accumulations)
- impairment of the gastrointestinal tract
    - impairment of the respiratory tract (pulmonary oedema) upon inhaling cadmium-oxide fumes.

In addition, there is a risk of chronic poisoning such as:

- inflammation of the mucosa (known as the "cadmium cold")
- destruction of the olfactory epithelia
- bone defects

And, what is more, there is the suspected risk of a carcinogenic effect. This has been:

- clearly proved in experiments on animals, and therefore
- a carcinogenic risk cannot be ruled out for humans.

In view of these facts, cadmium *clearly* represents a health hazard to humans which must not be underestimated.

In future, therefore, parts containing cadmium are required to be replaced by parts which are free from it.

3 Alternatives to Cadmium

The non-use of cadmium raises technical and economic issues.

- Is there a comparable substitute?
- What is the price of such a substitute?

With regard to the first question:

Yes, there are comparable substitutes, such as zinc and zink-nickel platings, or even alloyed special steels.

With regard to the second question:

Alternative products hardly differ in terms of prices.

There are therefore no significant reasons for continuing to use cadmium.

4 "Health Hazard Cadmium" Project

The health risk emanating from cadmium provided the impulse for the Health Hazard Cadmium project.

Its objectives were to identify all units of equipment fit containing cadmium in the Tornado aircraft and to work out a concept for substituting the units affected.

4.1 Procedure for Identifying Assemblies Containing Cadmium

4.1.1 Compilation of a comprehensive Tornado Database

The approach we adopted was as follows.

First, a comprehensive Tornado database was compiled for this purpose.

For the compilation of this database, all available data sources were analysed and the logistical information were compiled with a view to the assemblies and parts containing cadmium

4.1.1.1 Data Sources

The following digital data sources were selected and evaluated for compiling this full database.

- Integrated Logistics Information System: ILIMS (Logistics Office of the German armed forces)
- Codification Project Number Directory (Logistics Office of the German armed forces)
- Illustrated Parts List: IPL (Materiel Office of the German Air Force)
- Illustrated Parts Catalogue: IPC (Materiel Office of the German Air Force)
- NATO Codification Coordination Tornado Data (CoCo Tornado) (Logistics Office of the German armed forces)
- Machine Decoding System: MDV, Characteristics of an item (Logistics Office of the German armed forces)
- Federal Logistics Data: FedLog (General Information System)
- Item of Supply Information System: ISIS (Defence Codification Agency)

- NATO Master Cross Reference List (NMCRL) (General Information System)
- Life Extension Tornado: LExTOR (ESG internal)
- Material Information Service: MID (ESG internal)
- Material Management System: MABS (ESG internal)
- Tornado Technical Publication (ESG internal)

This comprehensive Tornado database holds about 11.5 million data records at present and requires approximately 18 GB of storage space.

4.1.2 Identifying the Assemblies and Assigning the Parts

Using specific data fields, all the **assemblies, not parts,** in the Tornado aircraft are identified from this database.

The corresponding **parts** were then assigned to the assemblies.

Assignment was performed using a special data field named **Project Number**.

4.2 Identifying Assemblies Containing Cadmium

We have now come to the crucial point - identification of the assemblies containing cadmium.

To be in a position to classify an assembly as containing cadmium, it is first necessary to assess the individual components for cadmium.

But how is it possible to tell whether a part contains cadmium or not? It is not just a question of telling from a data record in a database whether a part contains cadmium.

At this point I would gain like to draw attention to the fact that the entire Tornado aircraft is involved, with several million data records.

4.2.1 Assessing Parts

The purpose of our procedure was to provide information on which parts contained cadmium and which did not.

Several methods were used for identification puposes.

4.2.1.1 Industry Surveys

First of all there were surveys of industry of different kinds. Letters were sent to component manufacturers, equipment manufacturers and repair companies.

They were requested to provide information regarding cadmium in their components and assemblies.

The surveys showed that component manufacturers were very co-operative by providing information on their parts which contained cadmium and those that did not.

We had a few problems with equipment manufacturers and repair companies.

Either the questionnaires were not completed or horrendous sums were asked for answers.

Only a few were prepared to provide information at a realistic cost-performance ratio.

4.2.1.2 In-House Procedures at ESG

A further, and very successful, method was the in-house procedure at ESG of assessing parts for cadmium.

This method involved retrieving the requisite data by means of specific database queries.

Using widely-ranging query routines which clearly exclude cadmium and routines which clearly point out cadmium, two groups were formed:

- a group of parts **not** containing cadmium, and
- a group of parts containing cadmium

The volume of data that had to be assessed was thus sucessively reduced.

4.2.1.2.1 Query Criteria

For forming these two groups, an in-depth analysis was performed on the different data elements and the contents of the different data fields.

It became apparent that the following data elements and data fields are suitable for an assessment.

Names

The name of an item of supply, for example, provides information on the group to which the item has to be assigned.

Names such as "O-ring, Neoprene“, "Insulating Piece“ etc. indicate that the parts do not contain cadmium.

Other names like "Nut cadmium plated“, "Washer cadmium“ are clear.

Descriptive Information

The descripive data are likewise very important.

Descriptive data characterise a part in greater detail in respect of its features and characteristics. Thus it is possible to find information on the dimensions, type of housing and, in some cases, the **surface treatment**. Cadmium and non-cadmium parts can now be acquired by these methods.

Standards

Analyses of standard parts – for example, PAN, DIN, LN, ISO, and VG - were also referred to for the purpose of assessing parts. The majority of standards contain a “Material Identifier”

which makes it possible to draw conclusions on the **material itself** or on its **surface treatment**. Sometimes a whole group of standards provides information on the material used.

Part Number

It is possible to determine, from the way in which some part numbers are written, whether they relate to cadmium or non-cadmium parts. **Words** such as nylon, PVC, insulating or cadmium-plated, and **material identifiers** and **abbreviations** such as GALZN, CRNI, B2A, B1B, GALCD, which are included in part numbers in many cases, are a guide to classification with regard to cadmium.

Group/Class

Further, certain groups and classes such as “All Rubber and Cushion Tyres”, “Fibre Ropes, Cordage and Strings”, “Packing and Sealing Material”, “Non-Metallic Tubing and Branch Pieces”, “Chemicals” etc. do **not contain cadmium parts** and thus come under the category of non-cadmium parts.

Code

Data fields with specific codes such as the **unit of issue code** can help identify **non-cadmium** parts. All parts whose code specified a **liquid** were placed in the non-cadmium category.

5 Results

What were the results of the identification:

The results of the identification were the Cadmium-Database.

This databse contains the assemblies which contain cadmium including there parts containing cadmium.

It further became evident that the results of the in-house procedure at ESG were in very good agreement with the results of the industry surveys.

The distinct advantages of the in-house method at ESG are ascribable to the database procedure, which results in a cost-effective result.

A quantity assessment of the results shows, that 72 % (of 1736, 1249 contain cadmium) of the assemblies of the equipment fit contain parts containing cadmium.

28 % of the assemblies are cadmium free.

Further on an analysies of cadmium parts shows, that 10.542 parts contain cadmium.

If it is taken into account that the parts are used more than once, cadmium parts are to be found at approximately 1.2 Mill locations at the present time.

The components containing cadmium are predominantly attaching parts and common-fit items such as screws, nuts, washers and electrical connectors which, of course, are frequently used on an assembly.

The number of design parts is low. Furthermore, they normally occur only once on an assembly.

The identification phase has already been implemented and accepted.

The following section describes a concept that has already been discussed. Substitution has not been implemented so far and will take a while. The problem is the legal situation in the European Union, which is not yet as strict with regard to marketing and using cadmium as it is with asbestos and PCB/PCT etc.

6 Concept for Substitution

How does one proceed to come to terms with a relatively manageable number of parts with a high frequency of occurrence with regard to substitution?

An important criterion with regard to substitution is categorisation of the assemblies.

Two criteria could be taken for this categorisation:

- Assemblies with many cadmium parts,
- And assemblies which have a high number of contacts with cadmium in the course of maintenance work.

The maintenance work is an important criterion because during this work personnel come in contact with cadmium.

There is a permanent health risk if you work with parts containing cadmium !

The next step is designed to select pilot assemblies on the basis of these criteria.

The substitution should be realized together with the manufacturer of pilot assembly.

After the convertion the pilot assemblies should be subjected to functional testing.

The assemblies will be subjected to the different modification stages in the course of substitution. Requalification of an assembly will be initiated upon commencement of substitution by means of an EMAPF (Equipment Modification / Alteration Proposal Form) and will be completed upon successful conclusion of substitution.

Since the components containing cadmium are primarily common-fit parts (screws etc.), substitution can be performed at reasonable cost during repair activities.

After the pilot phase the substitution goes on with assemblies - first which have high priority than medium priority, than low priority.

Assemblies which include completely isolated parts containing cadmium and with which technical personnel do not come into contact have not been scheduled for substition for cost reasons.

The experience which is made during the substitution phase should be used for the the other assemblies.

With this procedure the Tornado could be freed from cadmium step by step.

This method is suitable for identifying and substituting hazardous materials - in the civilian market as well as the military sector - at any time.

Approaches to the implementation of environmental pollution prevention technologies at military bases

Cadmium, A Health Hazard Surface Treatment

May 05 - 07 1999
Budapest

Overview

- Introduction
- Cadmium-Related Health Risks
- Alternatives to Cadmium
- „Health Hazard Cadmium" Project
- Results
- Concepts for Substitution

Introduction

- **Legislation of health hazard materials**
  - EEC Directives imposed on the marketing and use
  - Implementation by passing legislation at a national level (in Germany: Chemicals Prohibition Regulation)
  - A few exceptions at the present legal situation

Introduction

- **Exceptions for cadmium**
  - aerospace
  - military sector

➪ ***Cadmium may still brought into circulation and used***

- **Hazards to humans and the environment arise from cadmium**
  - manufacturing
  - maintenance and repair jobs
  - disposal

Cadmium-Related Health Risks

- **Items containing cadmium**
  - Minimal risk simply by touching
  - Potential risk by processing and generating high temperature
    - grinding
    - filing
    - welding

➪ ***cadmiumoxid fumes (inhaling)***

- **Cadmium-plating process**

- **Waste disposal**

Alternatives to Cadmium

- **Comparable subtitutes**
  - zinc plating
  - zinc-nickel plating
  - alloyed special steels

- **Price of substitutes**
  - hardly differ in terms of price

➪ ***No significant reason for continuing to use cadmium***

Cadmium Metal (Cd)

- **Cadmium is a silvery white, shiny metal**
  - Good characteristics for corrosion protection

⇨ ***Surface treatment***

Hazards to Humans from Cadmium

- Impairment of liver and kidneys (accumulation)
- Impairment of gastrointestinal tract
- Impairment of respiratory tract through inhalation of cadmium oxide
- Inflammation of mucosa ("cadmium cold")
- Destruction of olfactory epithelia
- Bone defects
- Suspicion of ***carcinogenic effect***

➡ ***Substitution of cadmium***

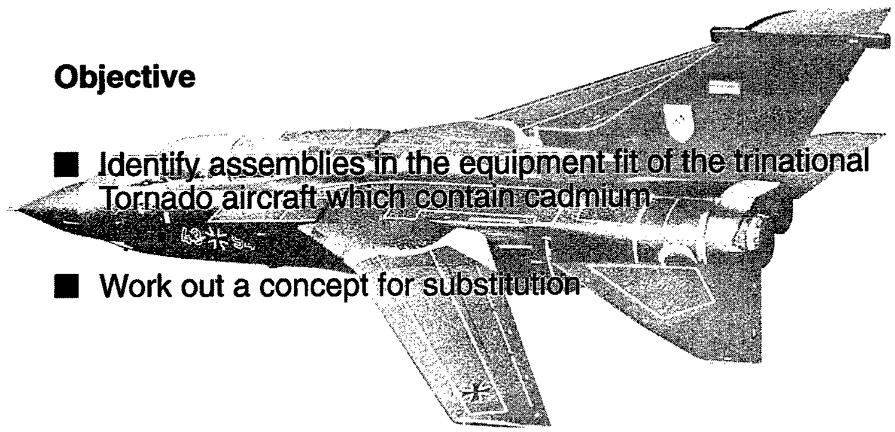
Cadmium

DV-44014

ESG

"Health Hazard Cadmium" Project

Objective



- Identify assemblies in the equipment fit of the trinational Tornado aircraft which contain cadmium
- Work out a concept for substitution

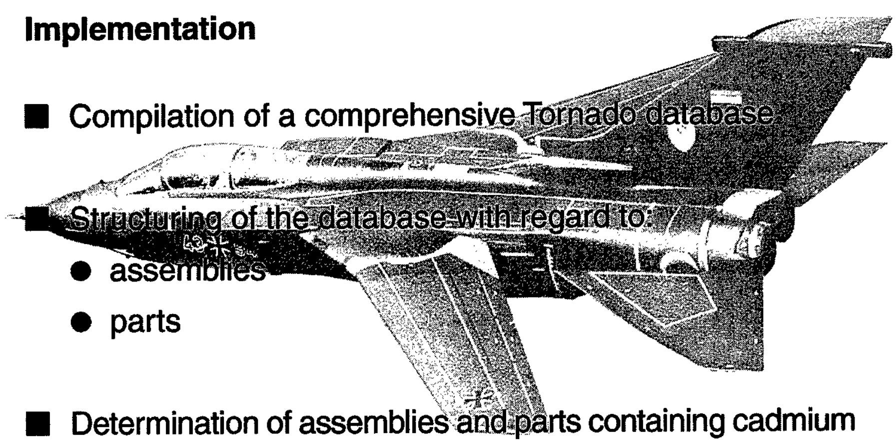
Cadmium

DV-44015

ESG

"Health Hazard Cadmium" Project

Implementation



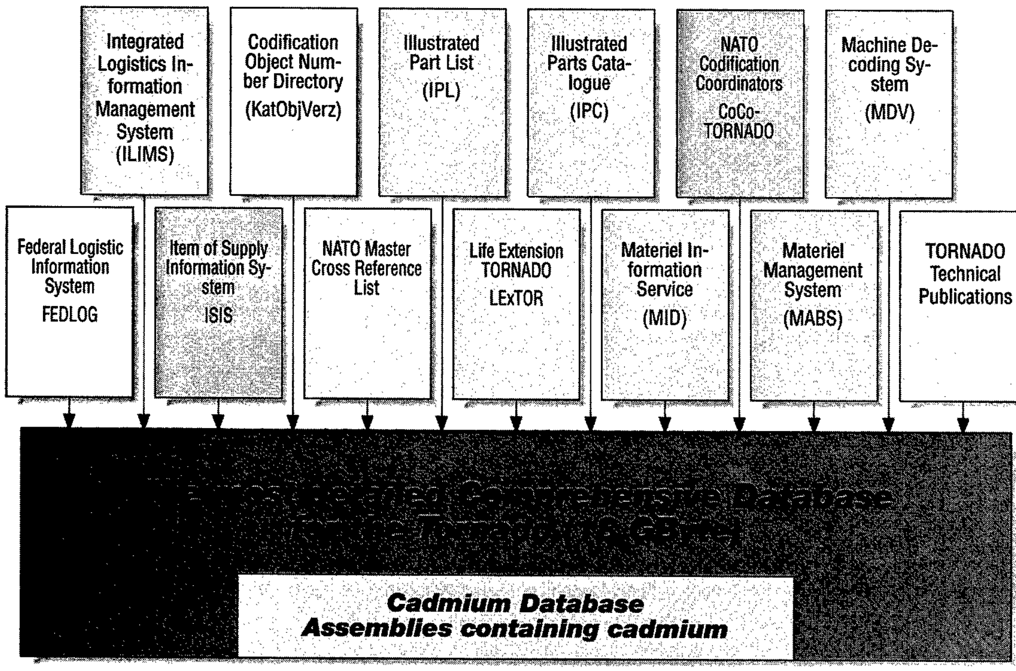
- Compilation of a comprehensive Tornado database
- Structuring of the database with regard to:
  - assemblies
  - parts
- Determination of assemblies and parts containing cadmium

Cadmium

DV-44016

ESG

Compilation of the comprehensive Tornado Database

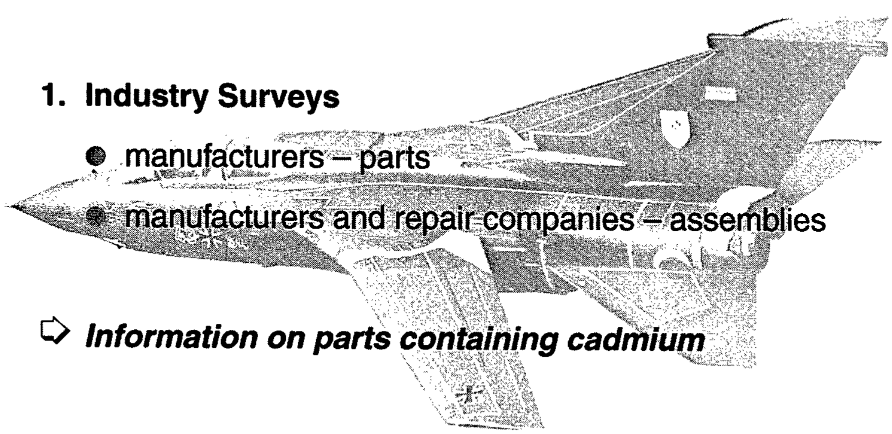


Cadmium

DV-44017

ESG

Identification of Assemblies Containing Cadmium



1. **Industry Surveys**
   - manufacturers – parts
   - manufacturers and repair companies – assemblies

➪ ***Information on parts containing cadmium***

Cadmium

DV-44018

ESG

Identification of Assemblies Containing Cadmium

2. In-house procedures at ESG

- Requisite data by means of specific database queries
- Split into two groups:
  - parts ***not containing cadmium***,
  - parts ***containing cadmium***

⇨ ***Volume of data that had to be assessed was sucessively reduced***

Cadmium

DV-44019

ESG

In-house Procedure at ESG

Names

- Name of on item of supply provides information on the group to which it has to be assigned

Descriptive Information

- Item of supply characteristics
- Details relating to material and surface treatment

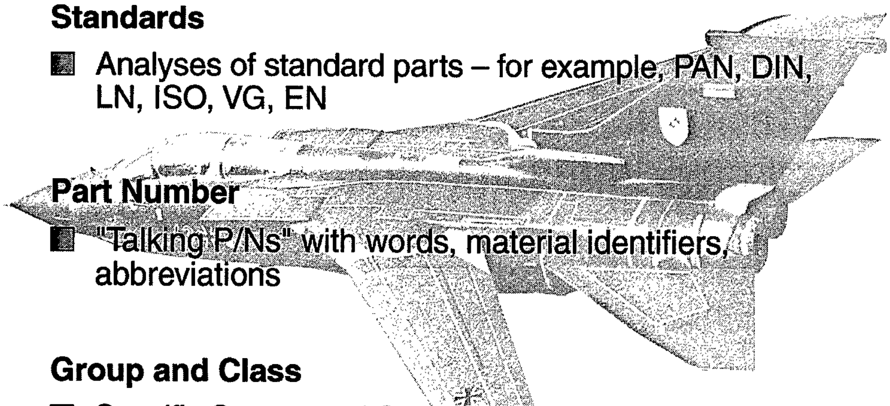
Coding

- Unit of Issue – for example, unit for specifying liquids

Cadmium

DV-44020

In-house Procedure at ESG



Standards

- Analyses of standard parts – for example, PAN, DIN, LN, ISO, VG, EN

Part Number

- "Talking P/Ns" with words, material identifiers, abbreviations

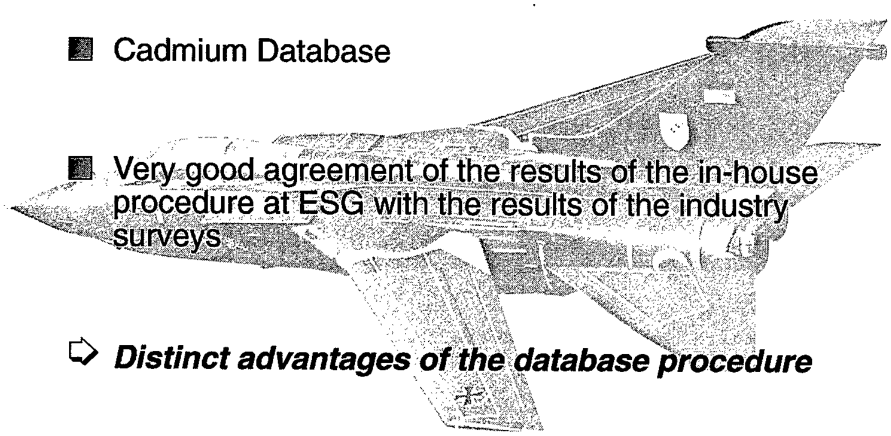
Group and Class

- Specific Groups and Classes do not contain cadmium

Cadmium

DV-44021

Results



- Cadmium Database
- Very good agreement of the results of the in-house procedure at ESG with the results of the industry surveys

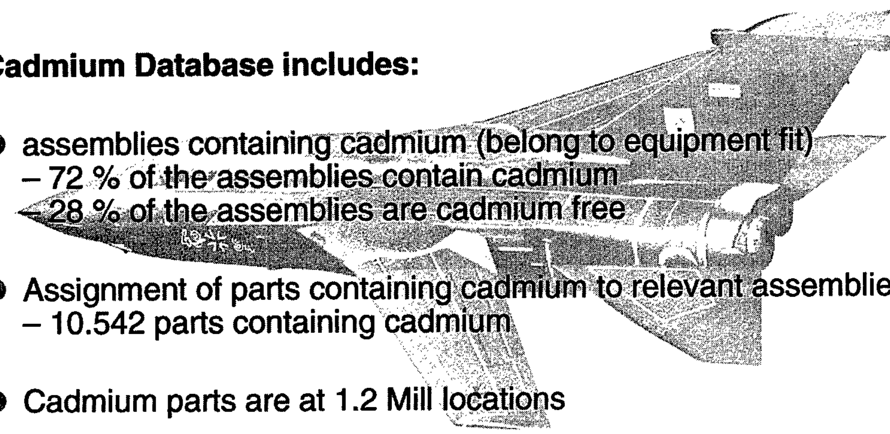
⇨ ***Distinct advantages of the database procedure***

Cadmium

DV-44022

ESG

Results



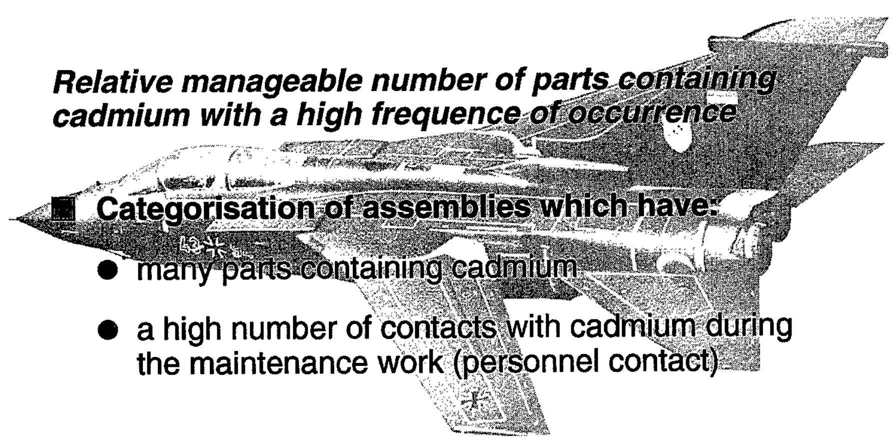
- **Cadmium Database includes:**
  - assemblies containing cadmium (belong to equipment fit)
    – 72 % of the assemblies contain cadmium
    – 28 % of the assemblies are cadmium free
  - Assignment of parts containing cadmium to relevant assemblies
    – 10.542 parts containing cadmium
  - Cadmium parts are at 1.2 Mill locations

Cadmium

DV-44023

ESG

Concepts for substitution



Relative manageable number of parts containing cadmium with a high frequence of occurrence

- **Categorisation of assemblies which have:**
  - many parts containing cadmium
  - a high number of contacts with cadmium during the maintenance work (personnel contact)

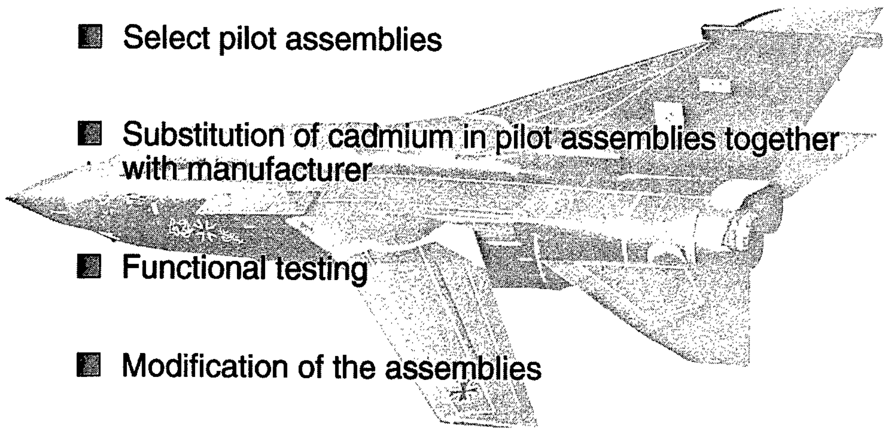
➡ ***Permanent health risk by working with parts containing cadmium***

Cadmium

DV-44024

ESG

Concept for Substitution

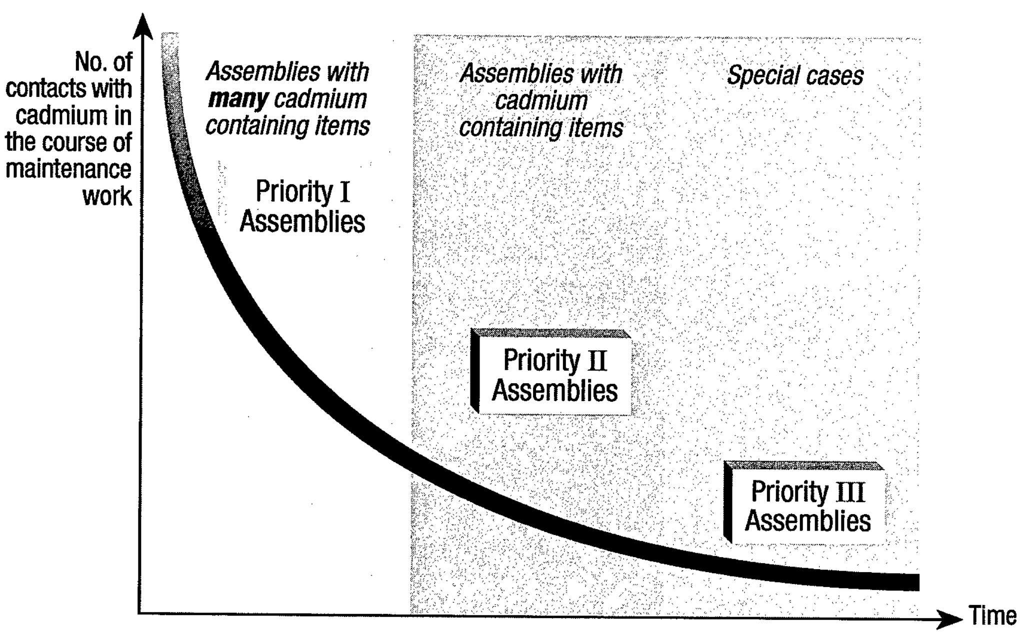


- Select pilot assemblies
- Substitution of cadmium in pilot assemblies together with manufacturer
- Functional testing
- Modification of the assemblies

DV-43787.e

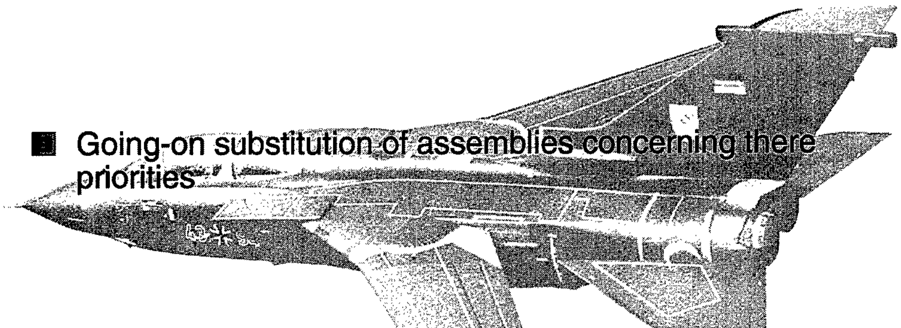
ESG

Assignment of Priorities to Assemblies



Cadmium ESG
DV-44025

Concept for Substitution

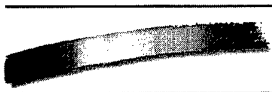


- Going-on substitution of assemblies concerning there priorities

➡ ***TORNADO could be freed from cadmium step by step!***

Cadmium ESG
DV-44029

Projects for Environmental Conservation at ESG


Substitution of Tritium containing Luminous Paints

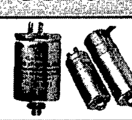
Substitution of Asbestos

Construction and Consumable Materials Database (WuV)

Operational and Auxiliary Materials Database (BuH)

Identification (and Substitution) of Cadmium containing Assemblies

DAVESUS/ SUBSTANZ
Dataprocessing Procedures of Substitution and Standardization


PCB
Substitution of Capacitors containing PCB

INFORMATION DISSEMINATION FOR POLLUTION PREVENTION

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INTRODUCTION

Pollution prevention for NATO and the Partners for Peace (PfP) nations within the framework of environmental security is a complex and pervasive issue. There are many facets to pollution prevention and reclamation of resources previously polluted by both military and civilian activities. NATO air, land, and sea military operations must take cognizance of these matters without unduly limiting or restricting their efficacy. And new understandings of the matter, changing natural environmental laws, and international agreements are generating a multitude of new approaches to coping with these issues.

As the NATO and PfP nations separately and jointly strive to develop processes and introduce new innovative approaches to solve these problems, there will be a large amount of experimental data that can be accumulated and shared. Much leverage may be realized with broad dissemination of the experiences of all the participating nations. The successes in one context or in one nation should be studied for applicability by others. Thus, it is most important to facilitate the timely dissemination of accurate and relevant data and analyses of each country's experiences.

Over the last three years, a project for the Committee on the Challenges of Modern Society (CCMS), the Environmental Clearing House System (ECHS), has developed a worldwide electronic data and information exchange system. The ECHS was developed with the understanding that the participants would be geographically widely separated and be serviced with widely different levels of computer capability and knowledge, and communications infrastructure. This system is a good model for methods to effectively disseminate information within the pollution prevention community.

THE WORLD WIDE WEB

An early decision in this implementation of the ECHS was to take advantage of the World Wide Web (WWW—also the Web), which in 1995 when the decision was made was still not in very wide use. The WWW was invented at CERN, the international particle physics laboratory that straddles the Swiss-French border near Geneva, Switzerland, in 1991. Its potential to facilitate information transfer amongst a very large, diverse, and geographically dispersed community was exploited in 1993 when the Web browser, MOSAIC, was developed at the University of Illinois at Urbana-Champaign, IL.

The WWW, which is an information transport protocol supported by the Internet, has driven the use of the Internet to spectacular levels. It is estimated that the number of people connected to the Internet today is approaching 200 million (over 4% of the world population). The number of registered Websites was 130 in June 1993, about 10,000 at the beginning of 1995 and today it is about 4.5 million. See Figure 1 for a graphic of this growth. This is the "information revolution" the origins of which may be traced in modern times to the building of the early fully electronic computers after World War II, e.g., the ENIAC in 1946. It is the amalgamation of computer technology and the communications infrastructure that has made this revolution possible.

Paper presented at the RTO SAS Symposium on "Approaches to the Implementation of Environment Pollution Prevention Technologies at Military Bases", held in Budapest, Hungary, 5-7 May 1999, and published in RTO MP-39.

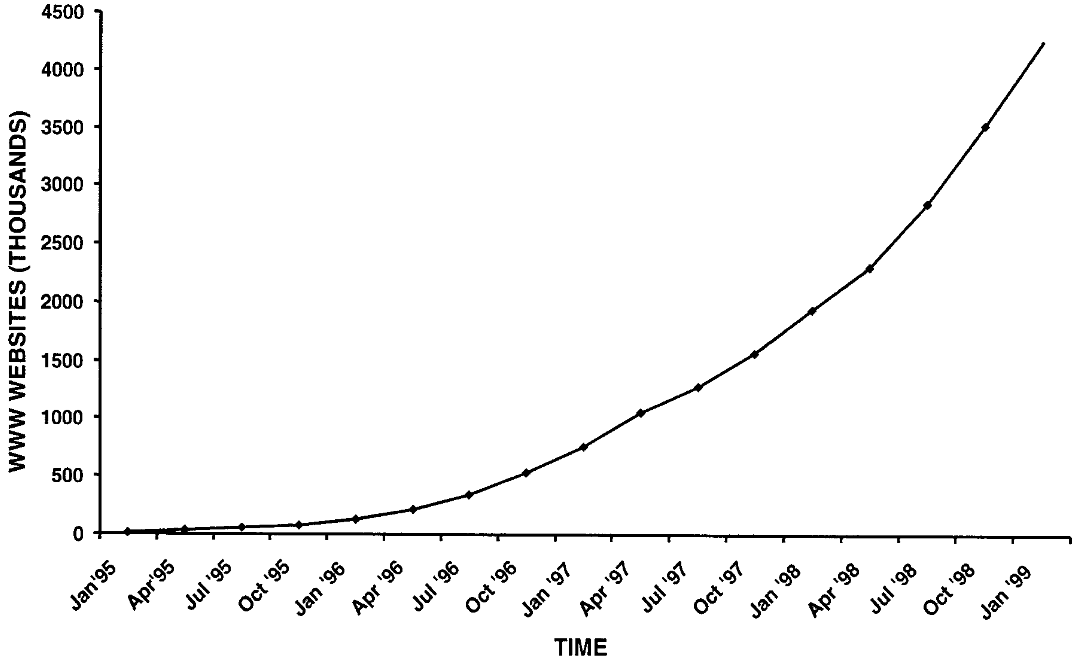


Figure 1. WWW Websites (Thousands)

A BRIEF HISTORY OF ECHS

In late 1994, the NATO CCMS directorate, recognizing the need for the establishment of a clearing house for environmental technical information exchange, initiated a program to develop the ECHS. The design for an experimental ECHS, based on the WWW, was done during early 1995, and by mid-1995 a test facility was up and running at IDA in Alexandria, VA, USA. The first public demonstration of the ECHS occurred in September 1995 in Swansea, UK, and a demonstration and training session for PfP representatives took place at NATO headquarters in Brussels in March 1996.

From early 1996 until early 1998 the ECHS was evolved from its early conception to a system more responsive to the needs of the environmental community. It was then time to transform the ECHS from an experimental program to a stable and professionally supported facility. This occurred in the first half of 1998 during which time there were ECHS sites both at NATO headquarters and at IDA. The experimental site was shut down in June 1998, leaving the permanent facility at NATO. Figure 2 indicates the usage level (number of requests for information) for the past two years.

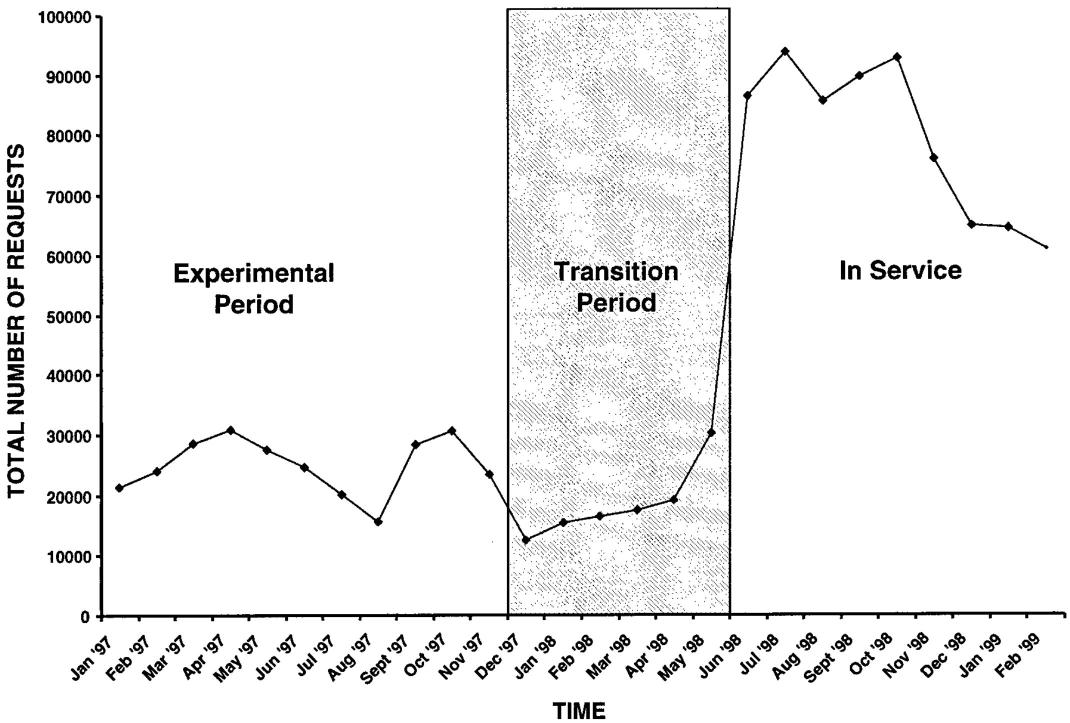


Figure 2. Total Number of Requests

The connectivity of the ECHS, similar to any Internet participant today, is shown as Figure 3. The information typically disseminated in the ECHS includes the following:

- NATO/CCMS overview
- Ongoing and planned CCMS projects
- Pilot study activities, briefings, papers, forums
- Announcements/calendar of events
- Pointers to other environmental Websites and information sources
- Technical reports
- Publications (environment related)
- Funding source information
- Surveys/results

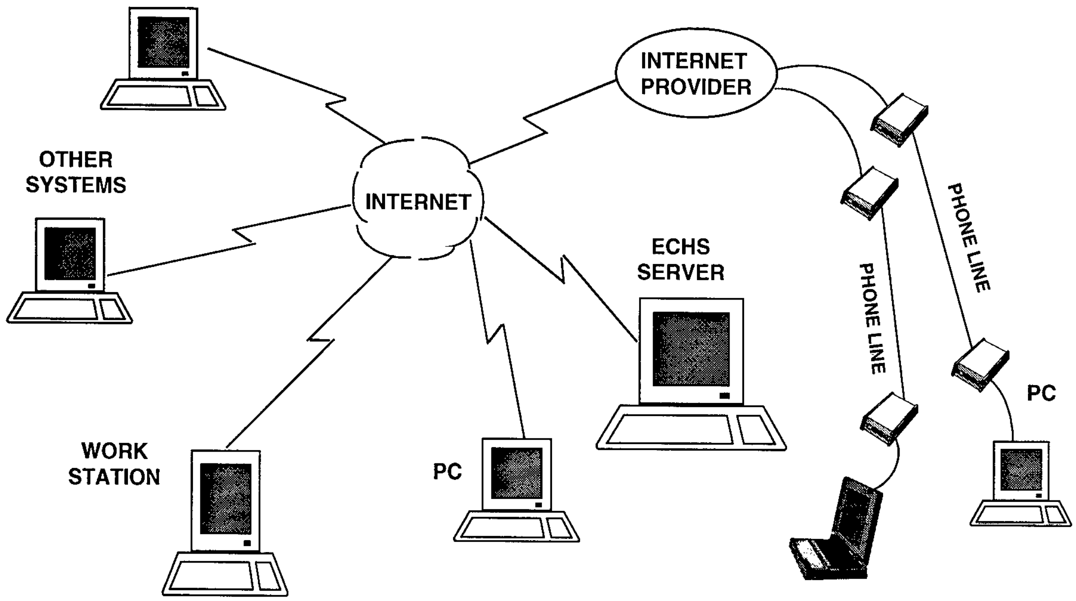


Figure 3. ECHS Connectivity

POLLUTION PREVENTION INFORMATION

The pollution prevention community would be well advised to take advantage of these new capabilities in information dissemination. The sharing of ideas, plans for action, lessons learned from experimental activities, and measured results of instantiated actions across NATO and PfP nations' pollution prevention communities will certainly leverage the activities of any single nation. The cost of participating in such an information exchange activity is very small and the potential rewards, e.g., learning about the successes of some other nations' effort, can be enormous.

In addition to sharing information amongst a well-defined group of participants, e.g., those represented here in Budapest at this symposium, using the WWW opens access to a very wide range of unclassified and non-proprietary information, including academic research papers, government and international organization reports, and information from the industrial sector. Furthermore, the WWW makes available a large number of "search engines" which makes it possible to search the entire Web for information on any topic, modified by the constraints on the topic of interest. The usual problem here is finding too much information on any given topic because it is quite difficult to delineate the detail of the information desired. This is a topic, a facet of data mining, of continuing major research activity in the information sciences community.

Examples of some of the Websites with large quantities of potentially interesting information on pollution prevention are listed here, each with their universal resource locator (URL):

- U.S. Department of Energy, Office of Environmental Management
  http://www.em.doe.gov
- U.S. Environmental Protection Agency
  http://www.epa.gov
- Central European Environmental Data Request Facility (CEDAR)
  http://pan.cedar.univie.ac.at
- U.S. Department of the Navy Environmental Program
  http://enviro.navy.mil
- Pacific Northwest National Laboratory Center for Environmental Security
  http://www.pnl.gov/ces
- Canada's Department of National Defense and the Canadian Forces - Environment Division
  http://www.dnd.ca/admie/dge/dge2e.htm
- U.S. Navy CFC and Halon Clearinghouse
  http://www.navyseic.com
- Global network of Environment & Technology
  http://www.gnet.org
- San Diego Bay Project
  http://www.sdsc.edu/sdbay
- EnviroLink Environmental Server
  http://www.envirolink.org
- Radiation Effects Research Foundation
  http://www.rerf.or.jp
- Argus Clearinghouse/Environment
  http://www.clearinghouse.net/cgi-bin/chadmin/viewcat/Environment?kywd++
- University of Virginia Environmental Library
  http://earthsystems.org/Environment.shtml
- U.S. National Institute of Environmental Health Sciences
  http://www.niehs.nih.gov/
- U.S. National Oceanic and Atmospheric Administration (NOAA) Environmental Information Services
  http://www.esdim.noaa.gov/
- BOI Technology Holding
  http://boitech.com/

Finally, to focus the symposium participants in this direction, the Proceedings of this Symposium will be made available on the NATO CCMS ECHS Website. (Note only those papers that are submitted to the organizers in electronic form will be available in this form.) The URL — the address — of the ECHS is:

http://www.nato.int/ccms

Once on this homepage, to get to the index page of the Symposium,

- Click on "Pilot Studies"
- This will bring up the Pilot Studies index page
- Click on the Symposium entry, which will be placed at the bottom of the Pilot Studies index page
- This will bring up the Symposium index page

NATO RTA/CCMS JOINT SYMPOSIUM
on
APPROACHES TO THE IMPLEMENTATION OF ENVIRONMENTAL POLLUTION PREVENTION TECHNOLOGIES AT MILITARY BASES

INFORMATION DISSEMINATION FOR POLLUTION PREVENTION

May 5-7, 1999

Dr. Alfred Brenner

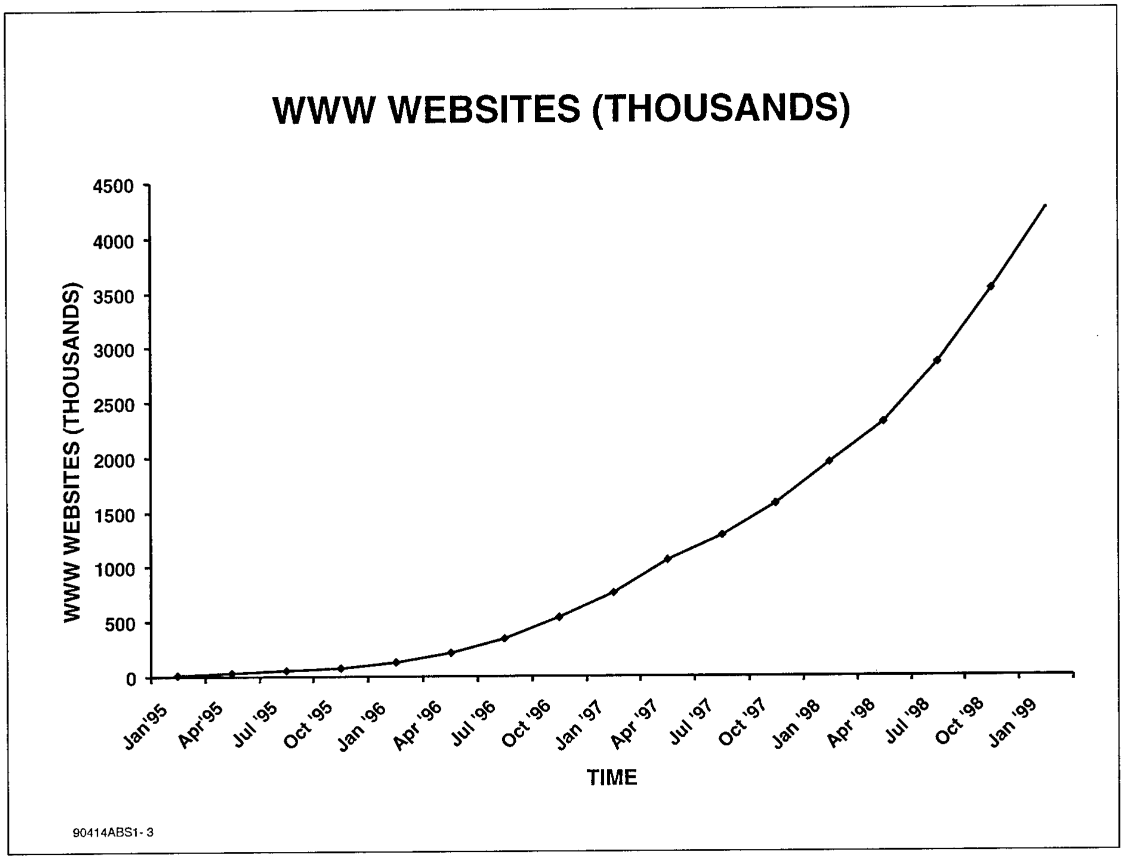
Institute for Defense Analyses
Alexandria, Virginia

90414ABS1- 1

THE INFORMATION AGE MILESTONES

- ENIAC 1946
- TRANSISTOR 1947
- SEMICONDUCTOR "CHIP" 1959
- ARPANET (→INTERNET) 1968
- MICROPROCESSOR (INTEL 4004) 1970
- APPLE II (→ IBM PC) 1978
- WORLD WIDE WEB (WWW) 1991
- BROWSER (MOSAIC) 1993

90414ABS1- 2



ECHS MILESTONES

• CCMS DIRECTORATE INITIATES ENVIRONMENTAL CLEARING HOUSE SYSTEM (ECHS)	NOV 94
• EXPERIMENTAL ECHS PROJECT INITIATED--INSTITUTE FOR DEFENSE ANALYSES (IDA) - US	MAR 95
– Decision To Use World Wide Web (WWW) Technology	
• PRELIMINARY ECHS OPERATION--ALEXANDRIA, VIRGINIA	JUN 95
• FIRST DEMONSTRATION OF ECHS--SWANSEA, UK	SEP 95
• ECHS DEMONSTRATION/TRAINING FOR PARTNERSHIP-FOR-PEACE REPRESENTATIVES--NATO HQ, BRUSSELS	MAR 96
• RESTRUCTURING ECHS ORGANIZATION	OCT-DEC 97
• PARALLEL ECHS SITES AT IDA AND NATO HQ	JAN-MAR 98
• TRANSFER OF ALL ECHS ACTIVITY TO NATO HQ	MAR 98

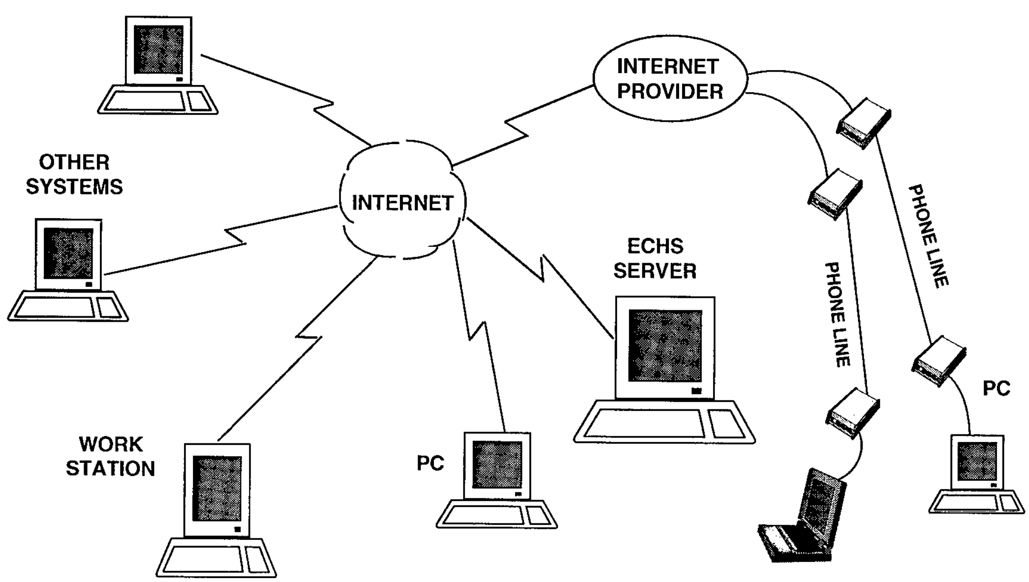
90414ABS1-4

ECHS CHARACTERISTICS

- BASED ON THE WORLD WIDE WEB (WWW) TECHNOLOGY
  - Easy Accessibility With A Variety Of Client Processors
  - Accessible Via Internet
- SUPPORTED ACTIVITIES
  - Information Sharing And Transfer
- RESTRICTIONS
  - No Classified, Restricted, Or Sensitive Information
  - No Functional (Remote) Computing
- CONTROL
  - Information Posting Controlled By Pilot Study Chairs
  - Access To Data Is Normally Unrestricted
  - Restricted Access Imposed Where Necessary--Passwords

90414ABS1- 5

ECHS CONNECTIVITY



90414ABS1- 6

ECHS INFORMATION CONTENT

- NATO / CCMS OVERVIEW
- ONGOING AND PLANNED CCMS PROJECTS
- PILOT STUDY ACTIVITIES, BRIEFINGS, PAPERS, FORUMS
- ANNOUNCEMENTS / CALENDAR OF EVENTS
- POINTERS TO OTHER ENVIRONMENTAL WEB SITES AND INFORMATION SOURCES (e.g., NATO, U.S. DOD / DOE / EPA / LIBRARY OF CONGRESS, ACADEMIA)
- TECHNICAL REPORTS
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90414ABS1- 7

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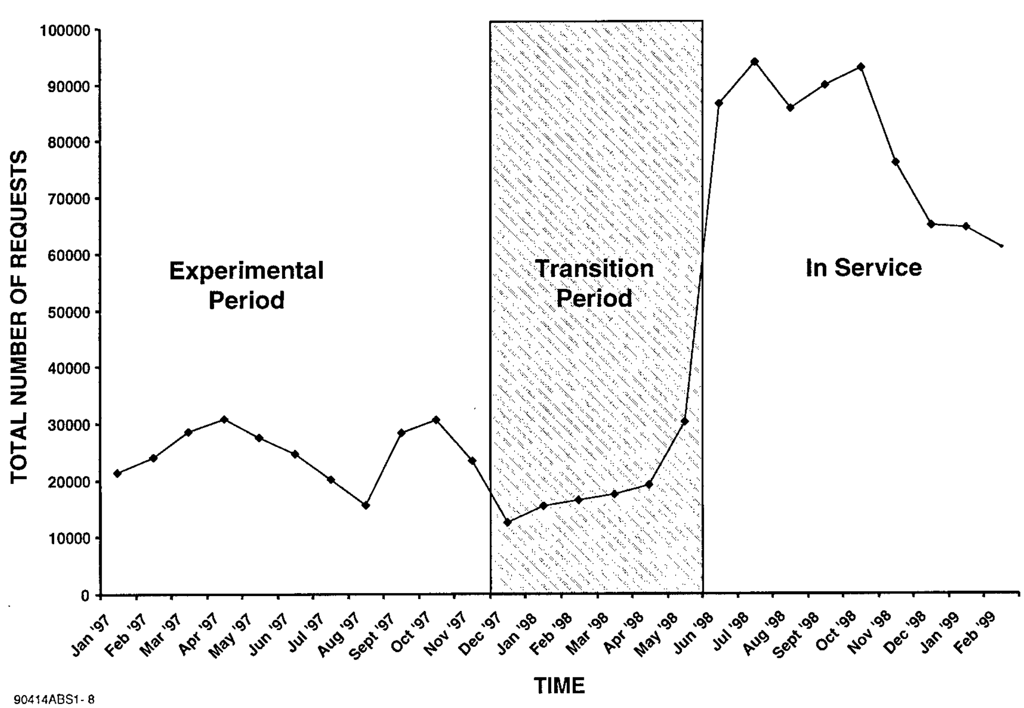

90414ABS1- 8

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- UNITED STATES
- SWITZERLAND
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Impact of Aircraft Emissions on the Global Atmosphere

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1. Introduction

Aviation is a very fast growing economic sector. For instance, in 1998 the number of passengers travelling with Deutsche Lufthansa grew by 9% relative to the previous year. Globally the annual increase rate in air transportation is more than 5%. The rapidly increasing demand for air transport outpaces technological improvements in aircraft and improvements in air traffic management systems: the mean annual increase rate of fuel burn was 2.2% for the years 1985 to 1995. Similar increase rates are expected for the future.

Aircraft emit gases (CO_2, H_2O, NO_x SO_2, UHC, etc.), aerosols (e.g., soot) and aerosol precursors (e.g., SO_3, H_2SO_4). Hence, aircraft modify the composition of the atmosphere either directly due to these emissions or indirectly via chemical processes, e.g., NO_x modifies the ozone concentration. The main concern related with these emissions is the potential for climate change by perturbing the Earth's radiative budget as a result of several processes: (1) the emission of radiatively active substances (e.g. CO_2 or H_2O); (2) the emission of chemical species which produce or destroy radiatively active substances (like NO_x, which modifies the O_3 concentration, or SO_2, which oxidizes to sulfate aerosols); (3) the emission of substances (e.g. H_2O, soot) which trigger the generation of additional clouds (e.g. contrails).

Due to the internal variability of the atmosphere, it is extremely difficult to detect the climatic impact of a single economic sector in climate observations or in simulations with comprehensive climate models. Therefore we consider the radiative forcing[2] (RF) associated with various perturbations of the atmospheric composition. RF is known to be a good predictor of global climate change in terms of variables like the global mean surface temperature change or mean sea level rise. On average the global mean surface temperature increases by 0.6 K per 1 Wm^{-2} of RF.

In the following we consider various individual contributions to the radiative forcing and concentrate on 1992 and 2050. While the current and past emissions of aviation are reasonably well known, we have no reliable forecasts of the future. Hence, we make use of emission scenarios, which have been developed for various economic and technological assumptions. We study in greater detail the aviation scenario Fa1 that makes similar economic assumptions as the IPCC scenario IS92a for all anthropogenic emissions. In the latter scenario the CO_2 concentration increases by 0.6% annually. The aviation scenario Fa1 assumes a mean annual increase rate of 1.7% for the fuel burn until 2050.

[1] corresponding author, email: robert.sausen@dlr.de

[2] Radiative forcing is the change of the net radiative flux at the tropopause, which instantaneously occurs after a perturbation of the atmospheric composition. Apart from a radiative adjustment of the stratosphere no changes are allowed to occur in the atmosphere before calculating RF.

Paper presented at the RTO SAS Symposium on "Approaches to the Implementation of Environment Pollution Prevention Technologies at Military Bases", held in Budapest, Hungary, 5-7 May 1999, and published in RTO MP-39.

2. Components to radiative forcing due to aviation

CO_2

The atmospheric life time (adjustment time) of CO_2 is in the order of decades to centuries. Hence, CO_2 is well-mixed within the atmosphere, and the location of the emission is not important. In 1992, about 1.2 ppmv of the atmospheric CO_2 was caused by air traffic. This is 1.6% of all anthropogenic increase (76 ppmv) since 1800. According to scenario Fa1 the aircraft contribution will increase to 6.3 ppmv until 2050 (2.9% of all anthropogenic CO_2 according to scenario IS92a). The corresponding aviation RFs are 0.018 and 0.074 Wm^{-2} for 1992 and 2050, respectively (Figure 1). For comparison, all anthropogenic CO_2 caused RFs of 1.5 and 3.8 Wm^{-2}, respectively.

O_3

The 1992 NO_x emissions of the subsonic air traffic lead to a calculated regional increase of the O_3 concentration of 3% relative to the unperturbed background (without aircraft) due to smog reactions. Following scenario Fa1, this value will double until 2050. Ozone is radiatively active in both, the solar and terrestrial ranges of the spectrum. The aircraft-induced ozone perturbations result in positive RFs of 0.023 and 0.06 Wm^{-2} for 1992 and 2050, respectively (Figure 1). The RF exhibits a strong latitudinal dependence: on the northern hemisphere it is about one order of magnitude larger than on the southern hemisphere.

CH_4

The NO_x emissions also increase the sinks for atmospheric methane (CH_4). Hence aviation results in a reduction of the anthropogenic increase of CH_4 (e.g., from rice fields). Therefore the net effect of aircraft is a negative RF due to the CH_4 changes: -0.014 Wm^{-2} in 1992 and -0.045 Wm^{-2} in 2050. However, as the atmospheric life time of CH_4 is in the range of a decade, CH_4 becomes well-mixed. Therefore the aviation methane effects cannot compensate for the aircraft ozone effects due the different regional patterns of RF.

H_2O

Despite the fact that H_2O is one of the main emission products of aircraft engines, aviation H_2O cannot significantly disturb the background concentration of H_2O as it is effectively removed from the atmosphere by precipitation. Therefore the direct climate effect of water vapour from aviation is minor.[3]

Contrails

Water vapour emissions from aircraft trigger the generation of contrails (condensation trails) which can persist for tens of minutes to several hours for suitable background conditions. Due to the 1992 air traffic 0.1% of the Earth was covered by persistent contrails. In regions with heavy air traffic the computed coverage was larger: 1.1% over Europe and 1.4% over the USA. The global mean radiative forcing was 0.02 Wm^{-2}. The contrail coverage will grow more rapidly than fuel burn as modern, more efficient aircraft release a cooler exhaust for the same amount of fuel burnt than older aircraft do, and as relatively more fuel will be burnt at cruising altitude than at lower atmospheric levels. According to scenario Fa1 the global mean coverage by persistent contrails will increase to 0.5% until 2050 with a RF of 0.1 Wm^{-2}.

[3] The situation is totally different for a projected large fleet of supersonic aircraft: for this scenario the water vapour effect is dominant.

Aerosols
Both, sulphate and black carbon (soot) aerosols only have a very small direct radiative effect on climate.

Clouds
Aerosols from aviation may accumulate in the atmosphere and may have a significant impact on the "natural" cirrus cloudiness. However, apart from single cases where aircraft aerosols caused measurable changes of cirrus particle properties, we do not know enough yet in order to quantify the indirect effect of aircraft on clouds. Some very preliminary estimates of RF due to changes in cirrus cloud cover range from 0 to 0.04 Wm^{-2} for the 1992 climate.

3. The summed aircraft effects

Figure 1 compares the various contributions of aircraft-induced RF for 1992 and for scenario Fa1 in 2050. Obviously, the contributions due to CO_2, O_3 and contrails are of similar magnitude. The CH_4 contribution also has a similar value, but is of opposite sign. All other contributions are at least one order of magnitude smaller.

In 1992 the total aviation RF (including contrails, but without other cloud changes) was +0.05 Wm^{-2}. This is 3.5% of the 1.4 Wm^{-2} for all anthropogenic activities. According to scenario Fa1 the aviation RF will increase to +0.19 Wm^{-2} until 2050 (5.1% of the 3.8 Wm^{-2} expected for all anthropogenic emissions under scenario IS92a). Other aviation scenarios result in an aviation contribution of about 10%.

Further details will be available from the forthcoming IPCC Special Report "Aviation and the Global Atmosphere".[4]

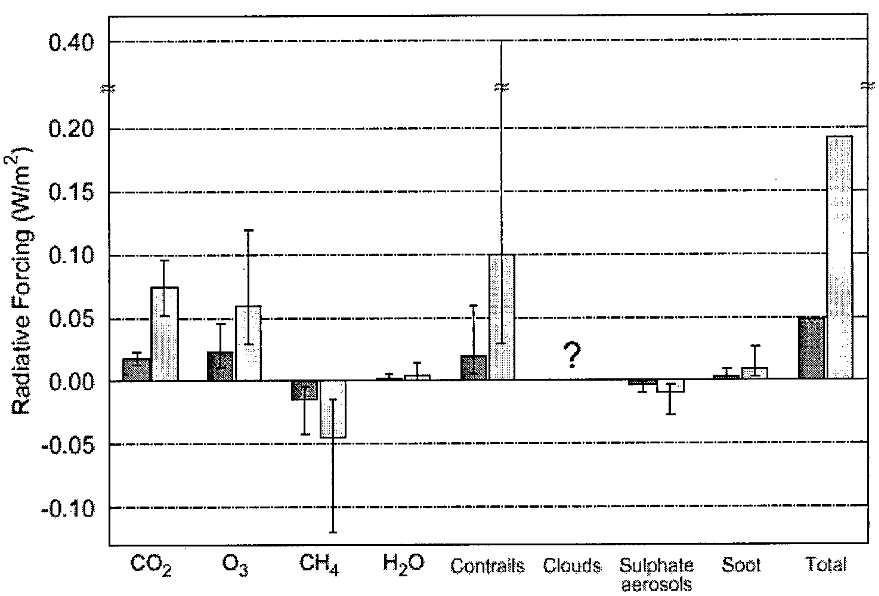

Figure 1: Components of radiative forcing due to aircraft for 1992 and for 2050 (according to scenario Fa1).

[4] This IPCC report will be published by Cambridge University Press in summer 1999.

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Impact of Aircraft Emissions on the Global Atmosphere

Information from the IPCC Special Report „Aviation and the Global Atmosphere"

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Joint RTA/SAS Panel and CCMS Symposium
Approaches to the Implemantation of
Environmental Pollution Prevention Technologies at Military Bases
Budapest, 5-7- May 1999

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Aviation and the Global Atmosphere - Contents (1)

Summary for Policymakers
Lister, Penner, Griggs, Houghton + 30 further LAs

1. Introduction
Ellis, Harris, Lister, Penner

2. Impacts of Aircraft Emissions on Atmospheric Ozone
CLAs: Derwent (UK), Friedl (USA); 6 LAs, 45 Cs

3. Aviaition-Produced Aerosols and Clouiness
CLAs: Fahey (USA), Schumann (Germany); 8 LAs, 21 Cs

CLA = Coordinationg Lead Author
LA = Lead Author
C = Contributor

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Aviation and the Global Atmosphere - Contents (2)

4. Modeling the Chemical Composition of the Future Atmosphere
   CLAs: Isaksen (Norway), Jackmann (USA); 9 LAs, 19 Cs

5. Solar Ultraviolet Irradiance at the Ground
   CLAs: Ryan (Australia), Frederick (USA); 3 LAs, 2 Cs

6. Potential Climate Change from Aviation
   CLAs: Prather (USA), Sausen (Germany); 4 LAs, 7 Cs

Aviation and the Global Atmosphere - Contents (3)

7. Aircraft Technology and its Relation to Emissions
   CLAs: Lewis (UK), Niedzwiecki (USA); 30 LAs, 11 Cs

8. Air Transport Operations and Relation to Emissions
   CLA: Bekebrede (The Netherlands); 9 LAs, 5 Cs

9. Aircraft Emissions: Current Inventories and Future Scenarios
   CLAs: Henderson (USA), Wickrama (ICAO); 12 LAs, 2 Cs

10. Regulatory and Market-Based Mitigation Measures
    CLAs: Hennigan (USA); 6 LAs

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Emissions

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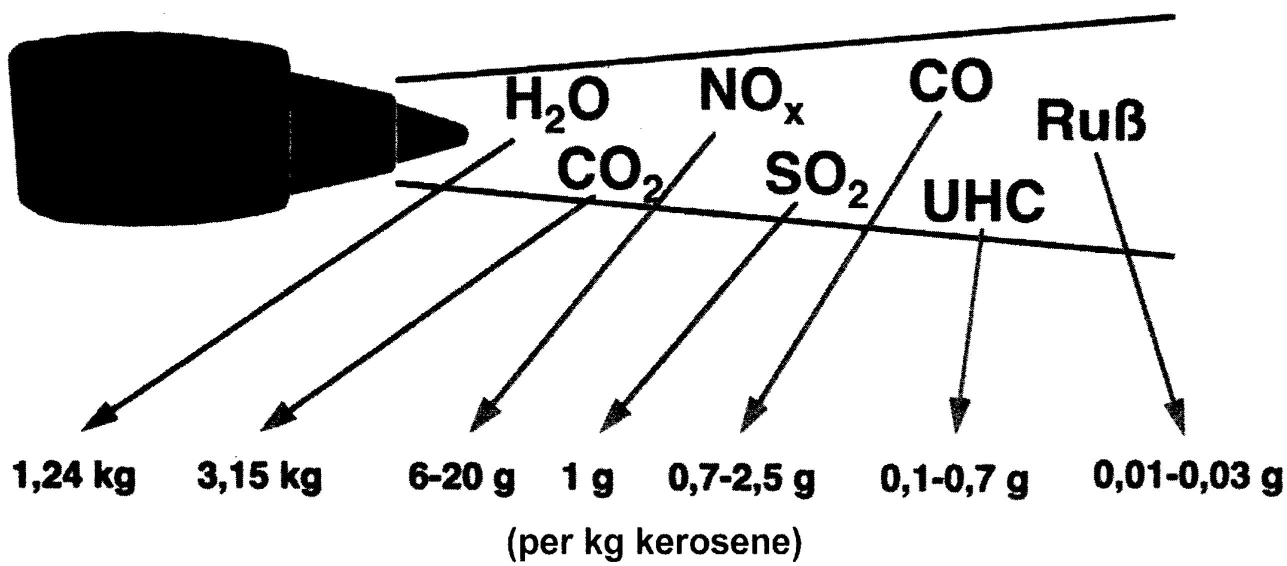
Aircraft emissions



DLR-Nachrichten 74 (Februar 1994)

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Figure 8-2: Aviation share of world transport CO_2 emissions

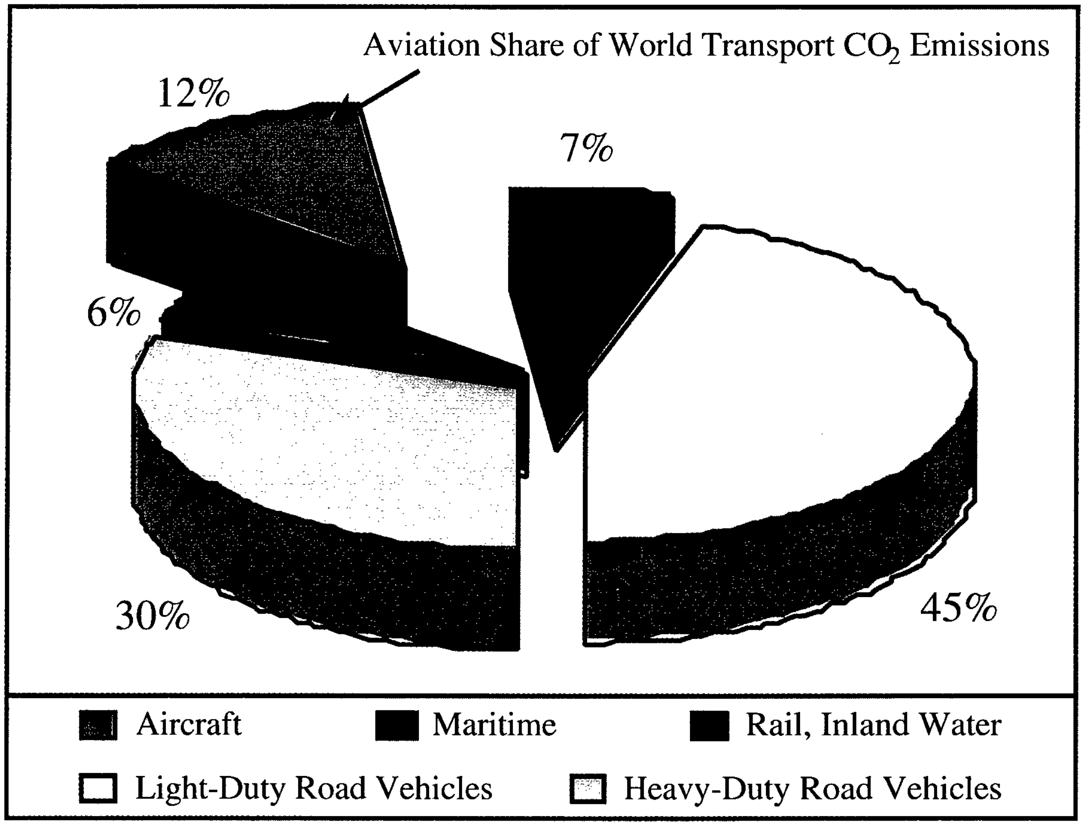


Figure 9-10: Geographical distribution of fuel burned by civil aviation (May 1992)

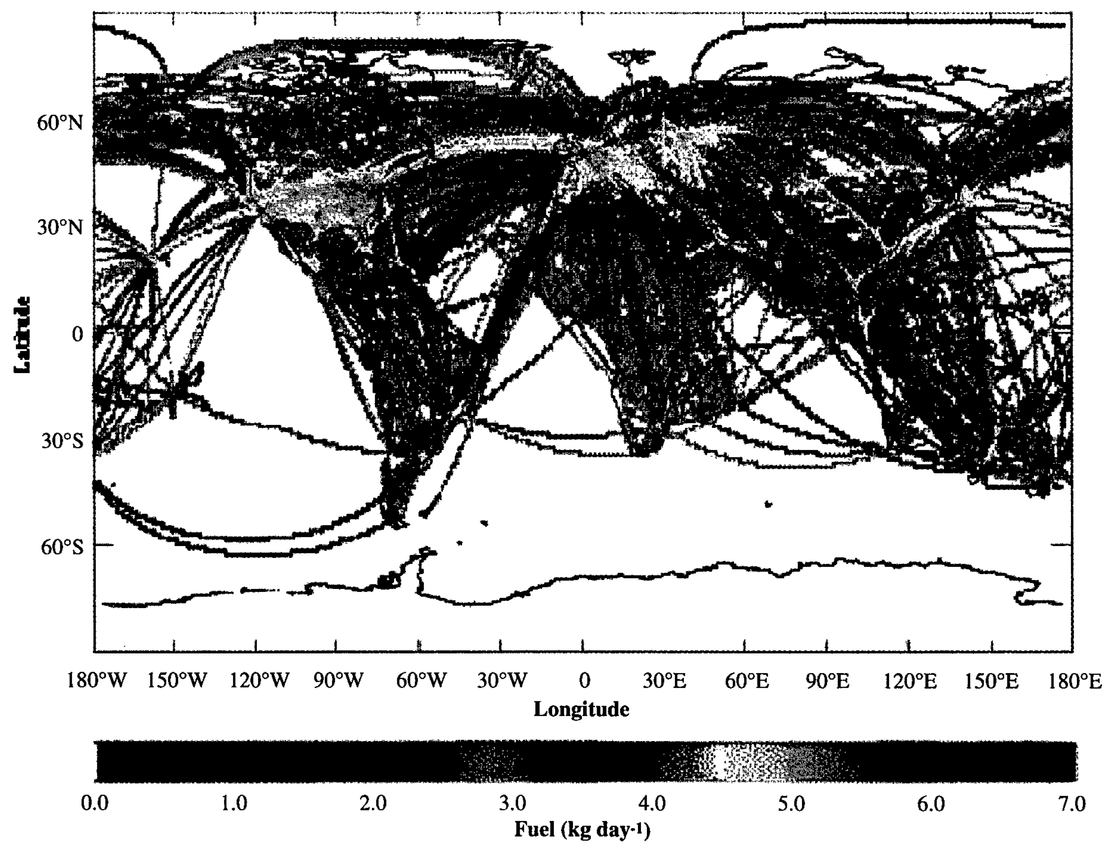
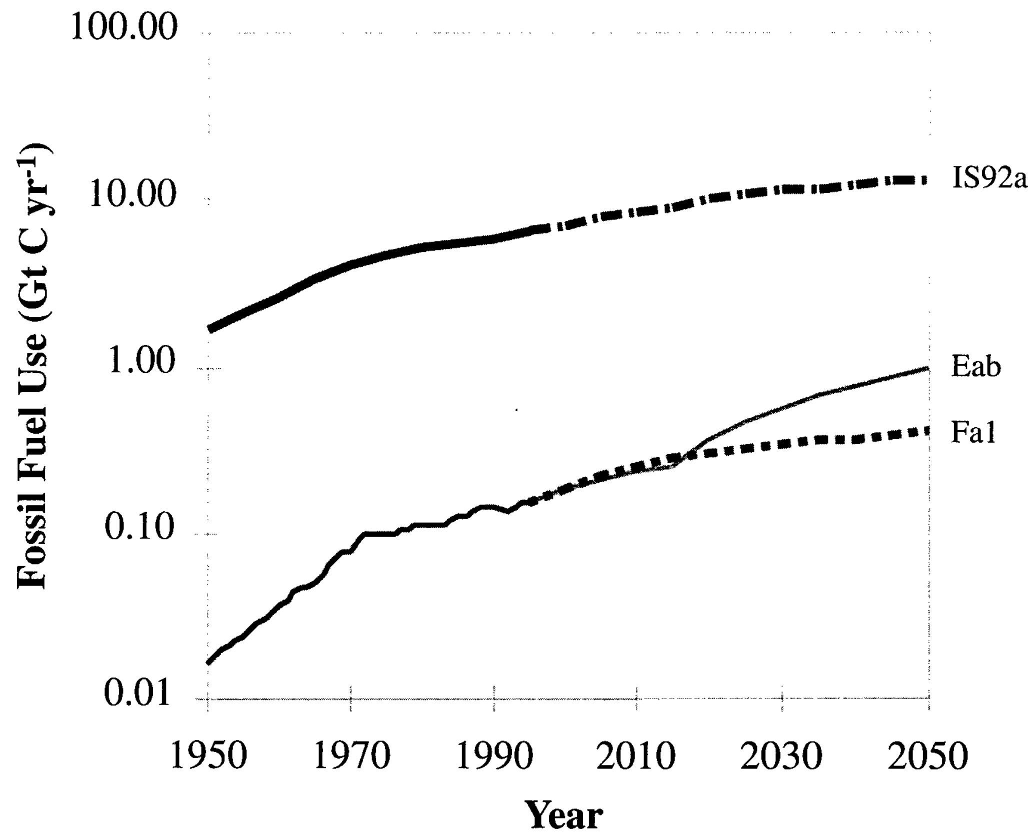
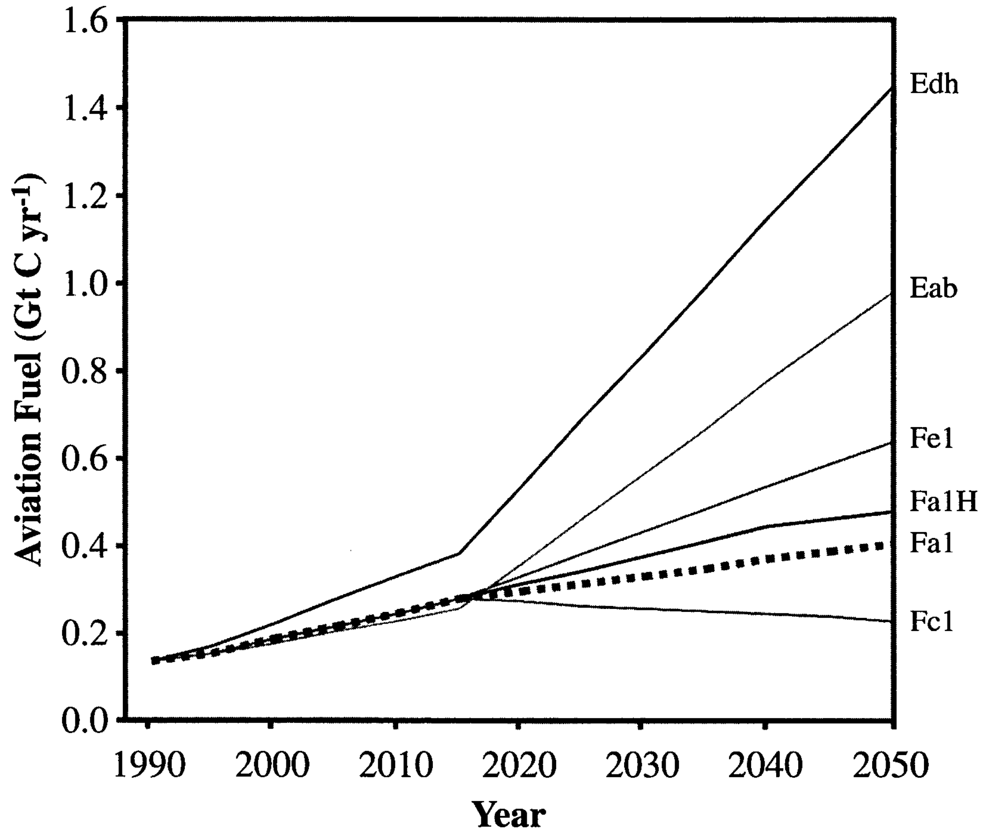


Figure 6-6: Fossil Fuel Use



Fossil fuel use (Gt C / yr) shown for historical aviation use (1950-1992, solid line) and for projected aviation scenarios Fa1 and Eab. The total historical fossil fuel use and the projection according to scenario IS92a (open circles) is also shown.

Figure 6-7: Aviation Fuel Use



Aviation fuel use (Gt C / yr) from 1990 to 2050 for the range of scenarios considered here.

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Impact on atmosphere and climate

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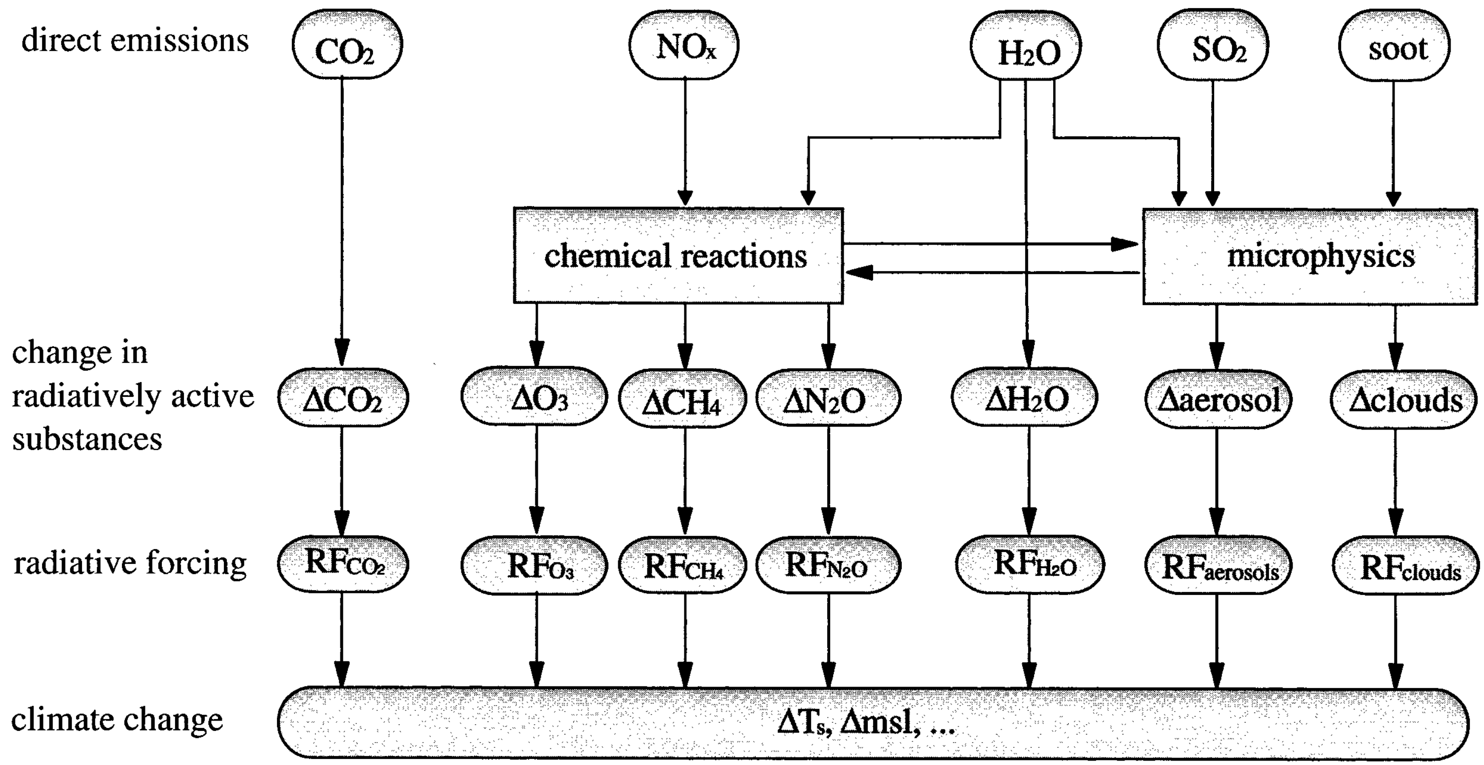
Figure 6-1: Climatic Impact of Aircraft Emissions



Schematic of the possible mechanisms whereby aircraft emissions impact climate. The climate impact is represented by changes in global mean surface temperature. (ΔT_s) and global mean sea level rise (Δmsl).

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Impact on the chemical composition of the atmosphere

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Figure 4-2: July zonal average increase in NO_X from aircraft

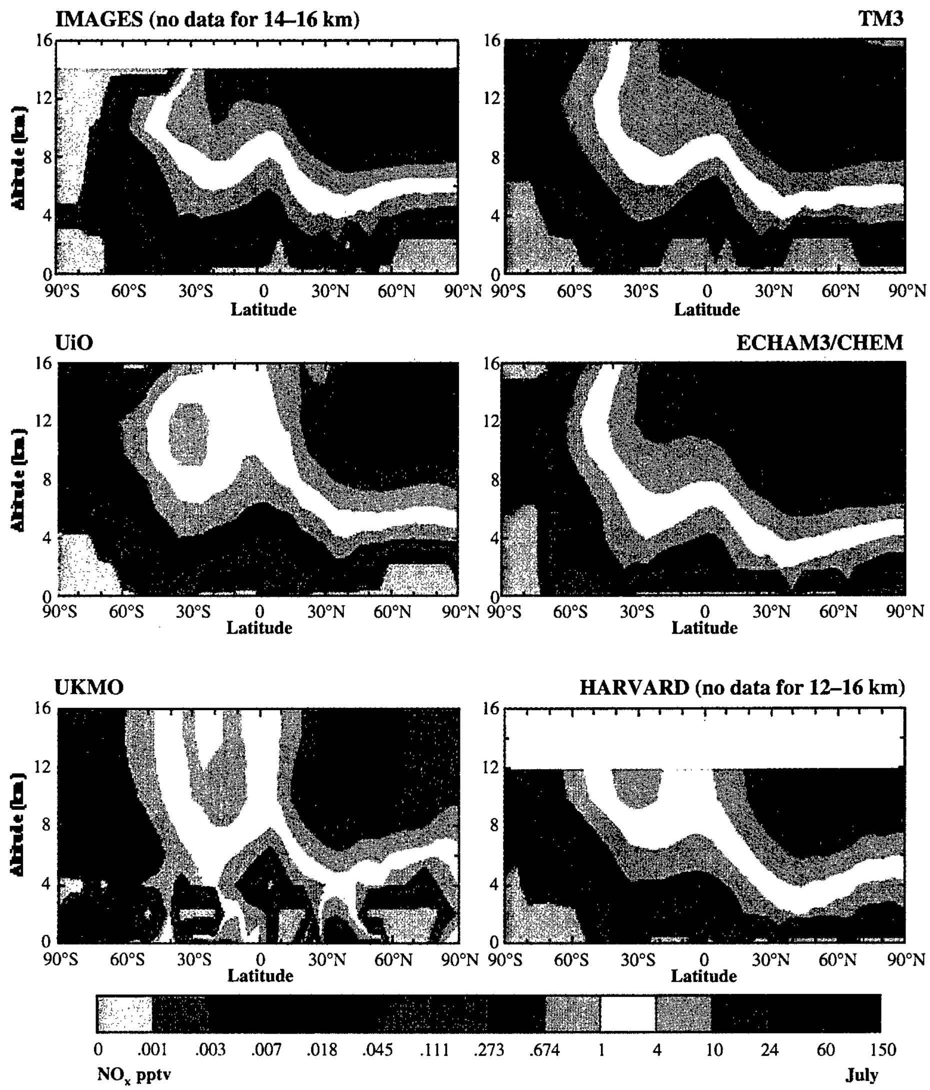
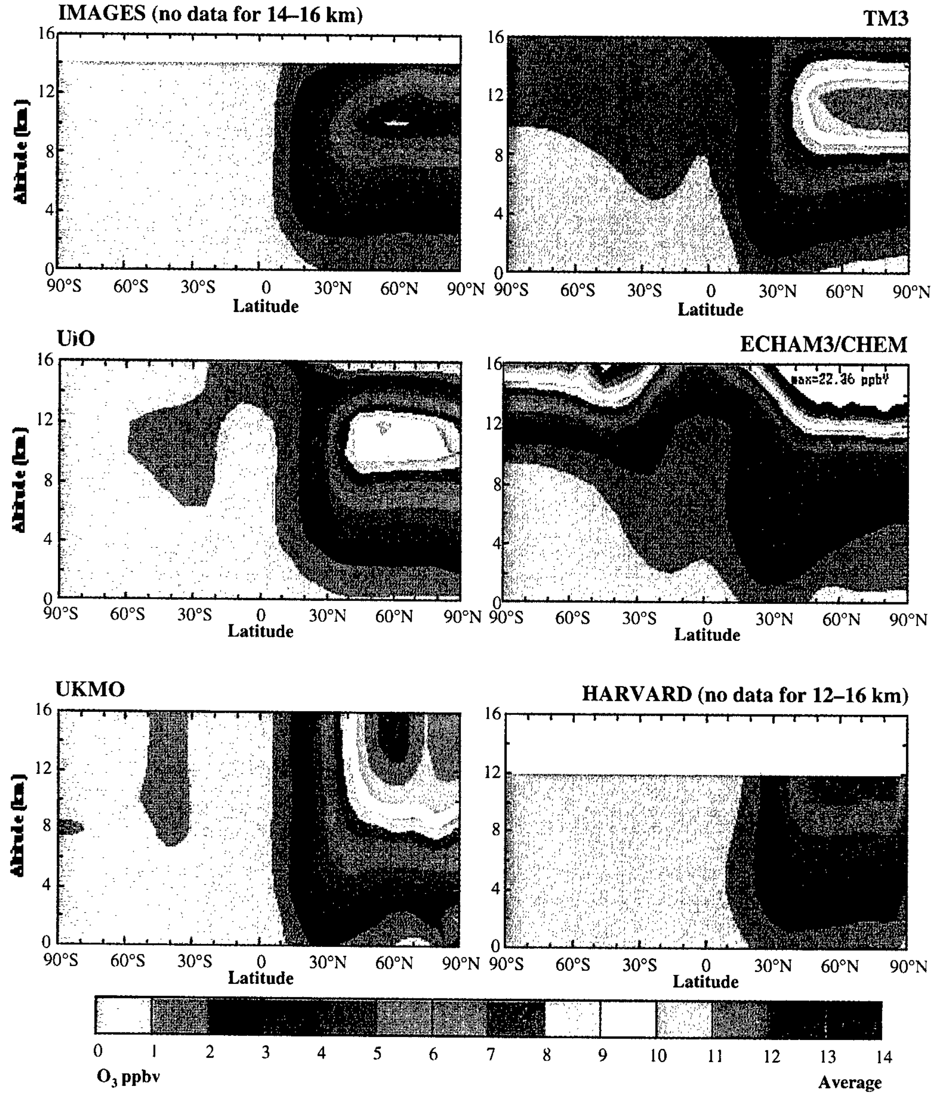
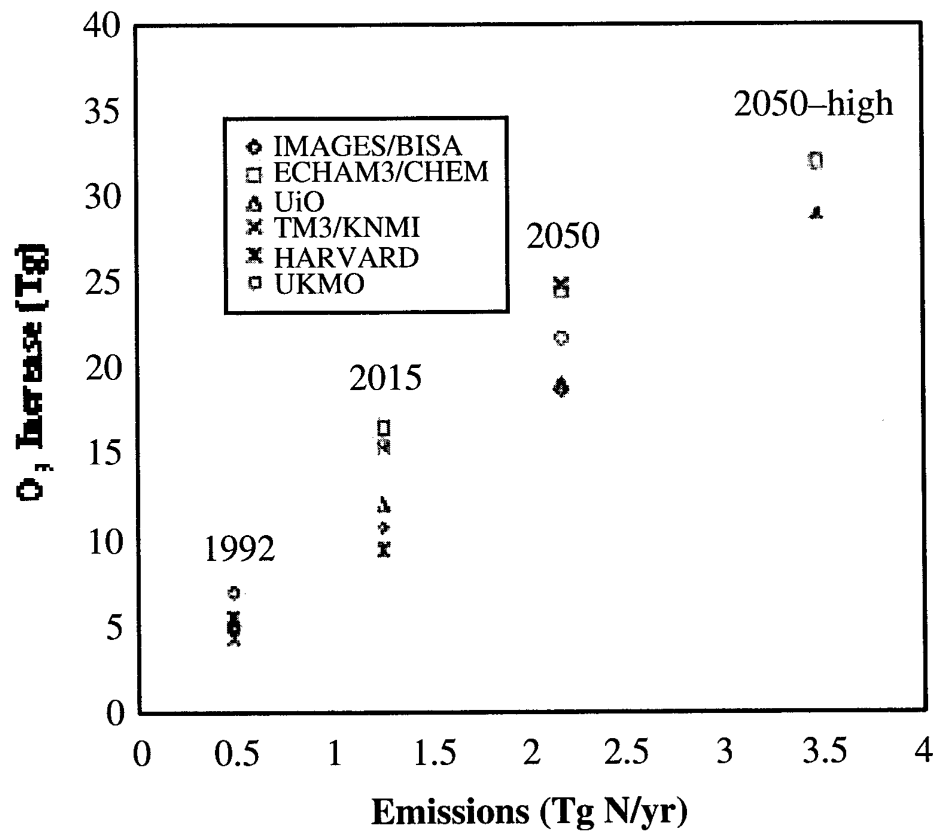


Figure 4-1: Annual and zonal average increases of O_3



Annual (2015) and zonal average increases of ozone volume mixing ratios from aircraft emissions [ppbv] calculated by six 3-D models. The IMAGES/BISAmodel does not give results above 14 km, and the HARVARD model does not give results above 12 km.

Figure 4-3: Increase in annual average global O_3 abundance



Increase in annual average global O_3 abundance (Tg O_3) up to 16 km from present and future aircraft emissions.

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Impact on clouds

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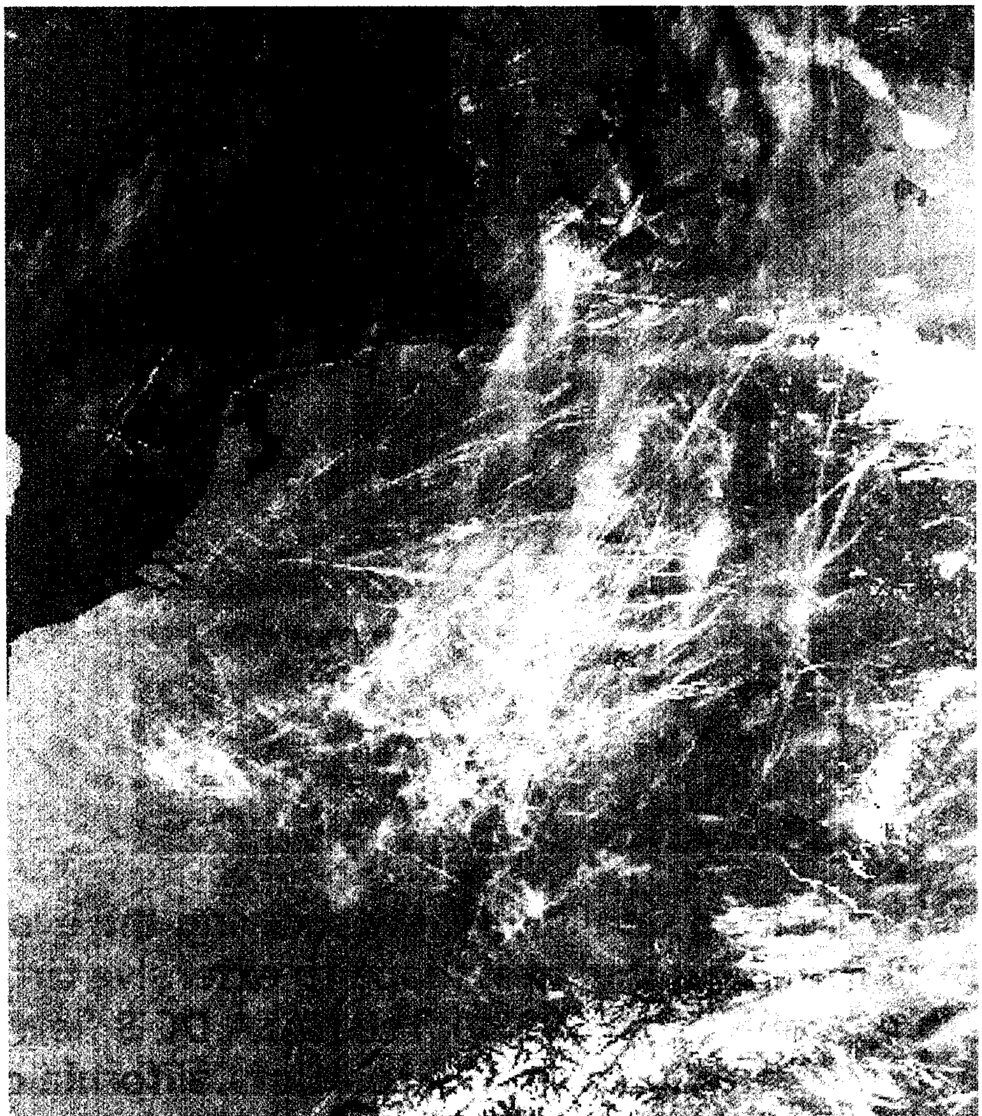
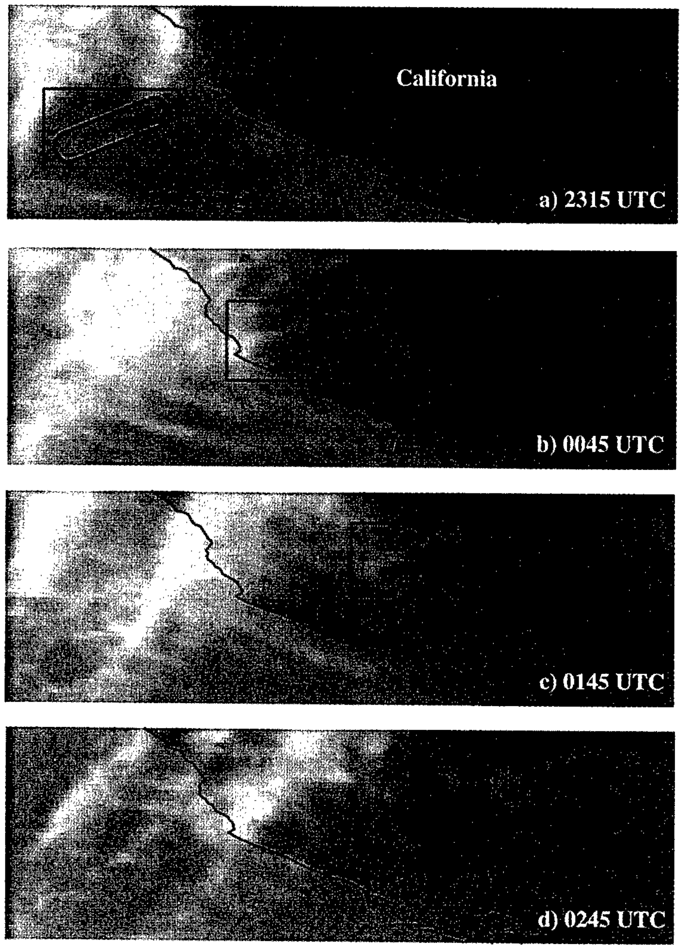
Figure 3-12: Contrails over central Europe



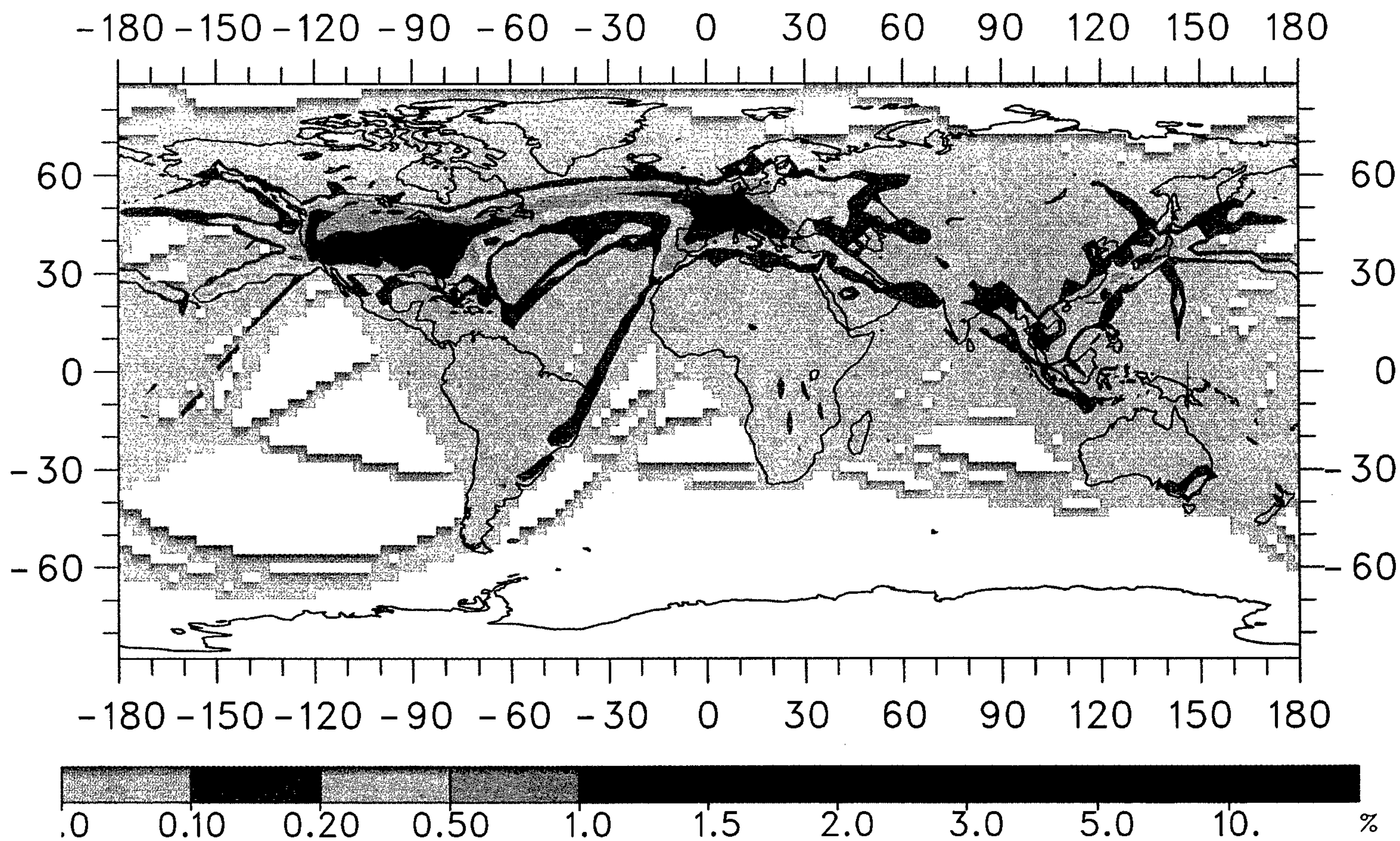
0943 UTC 4 May 1995, based on NOAA-12 AVHRR satellite data (from Mannstein, 1997)

Figure 3-13: Time series of GOES-8 satellite images

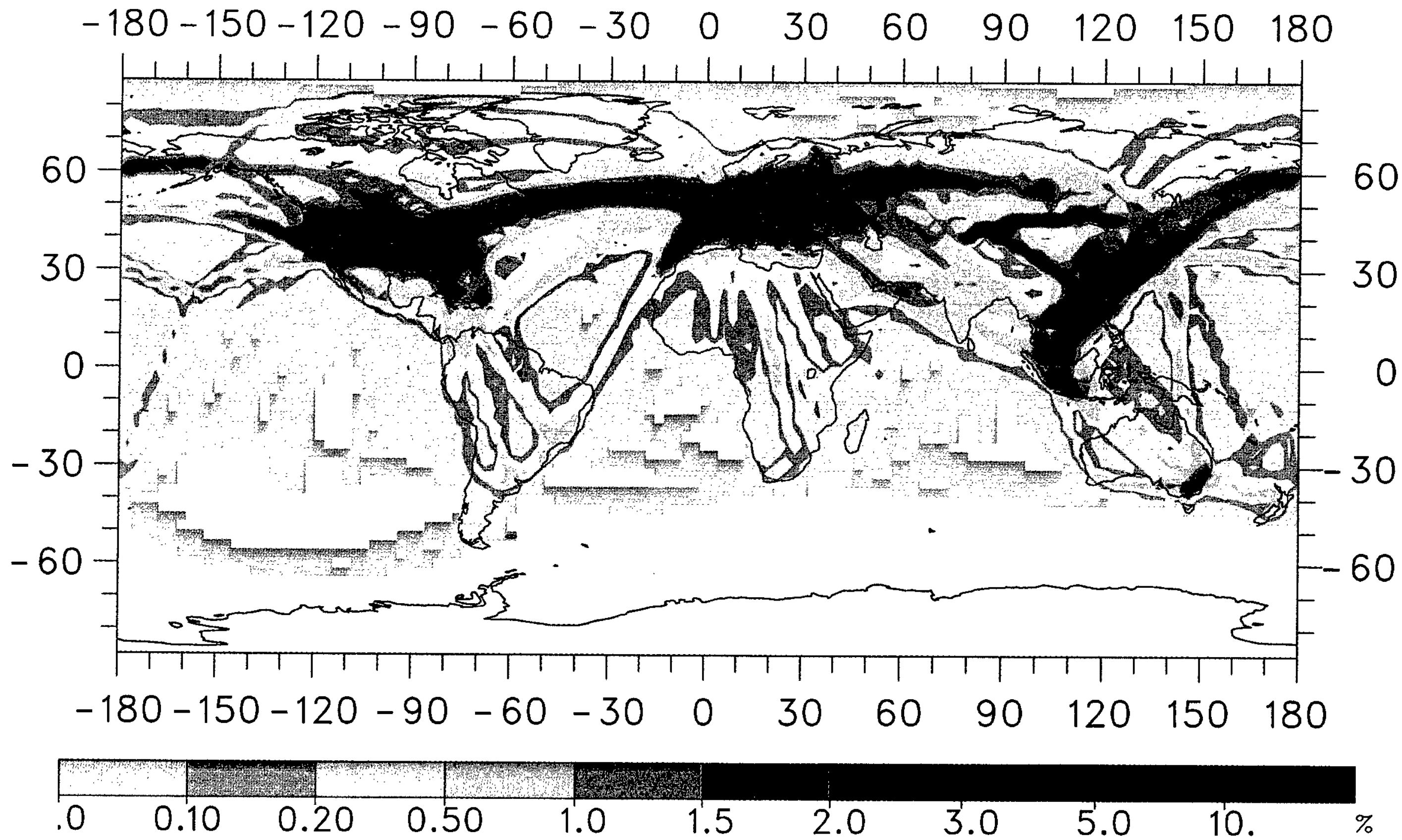


Time series of GOES-8 satellite images showing the evolution of a contrail from an initial oval shape to extensive cirrus clouds (from Minnis *et al.*, 1998a). The NASA DC-8 flew an oval flight pattern several times off the coast of California on 12 May 1996 (a), resulting in a visible contrail 15 minutes later (b). This contrail spread as it was advected over California (c), until it no longer resembled its initial shape 3 hours later (d). Satellite photographs courtesy of L. Nguyen of AS&M, Inc., Hampton, VA, USA.

Persistent contrail coverage (1992), η=0.3 linear weighting



Persistent contrail coverage (2050/1), η=0.5 linear weighting



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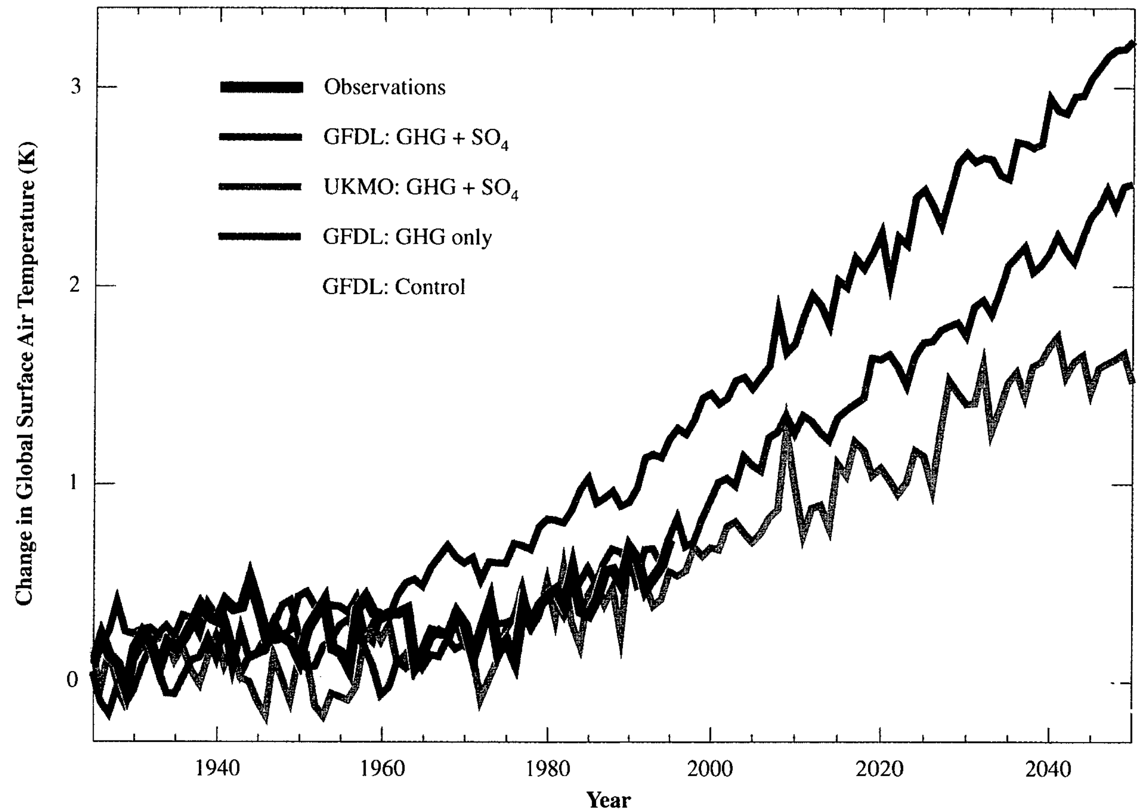
Impact on radiative forcing and climate

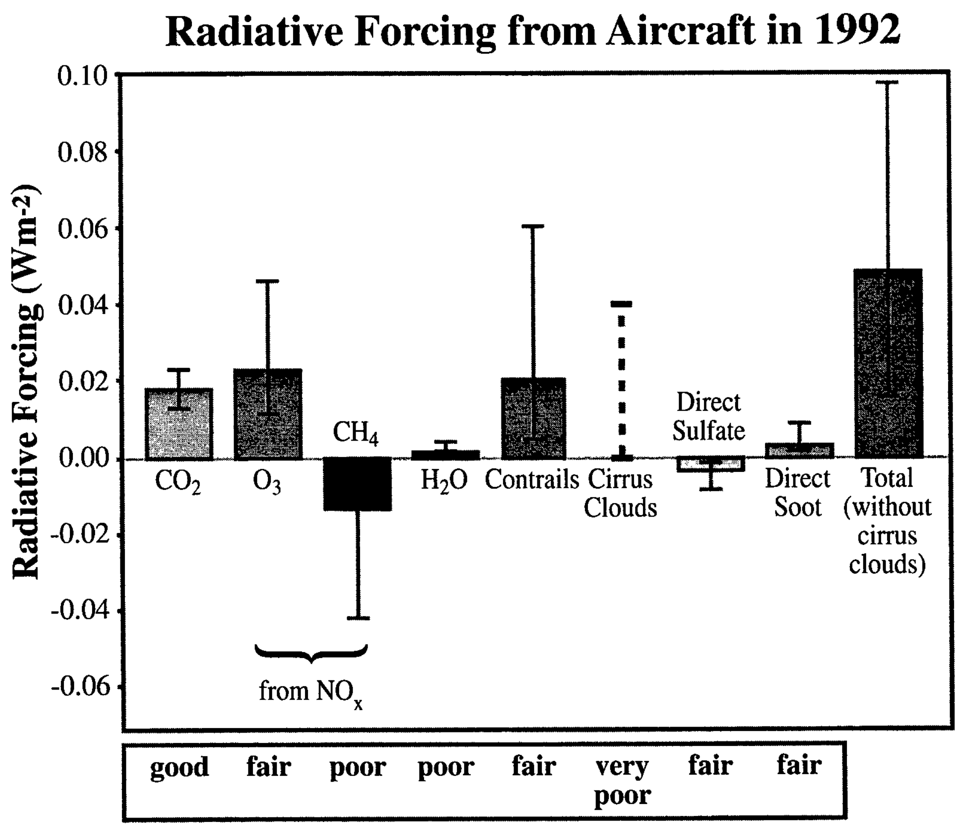
DLR

Figure 6-2: Change in Global Surface Air Temperature



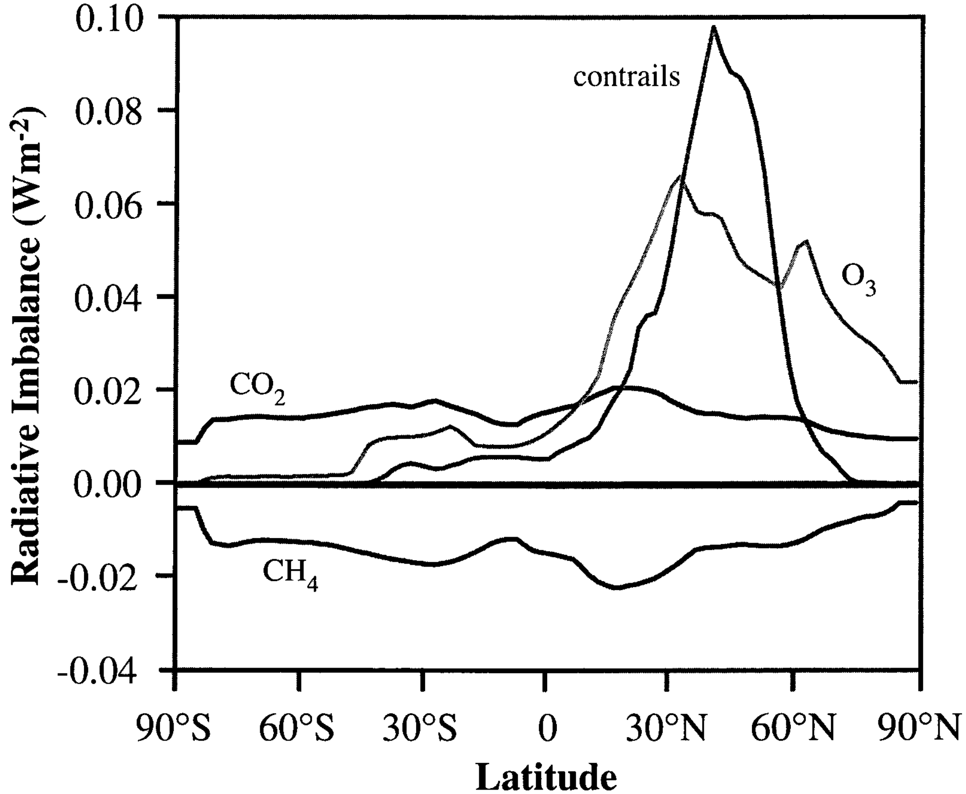
The change in the global mean surface air temperature (K). Observations are from Jones (1994) modified to include data up to 1995. GFDL data are from the modeling studies of Haywood et al. (1997b) and UKMO data are from the modeling studies of Mitchell et al. (1995).

Figure 6-14b: RF (Aviation, 1992)



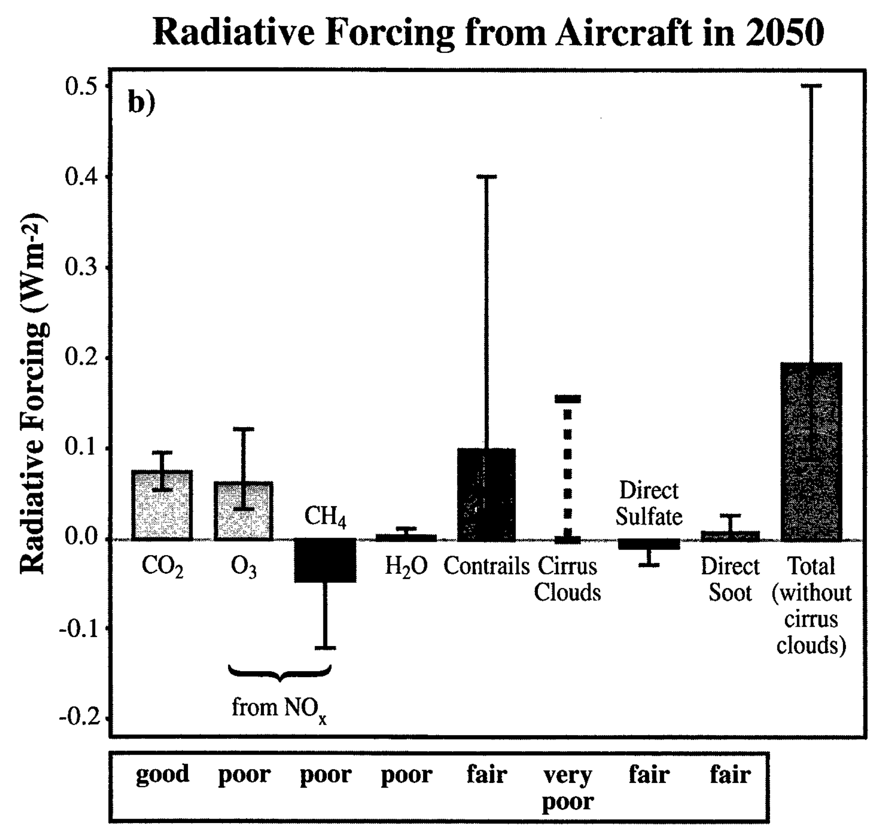
Bar charts of radiative forcing from aviation in 1992. The whiskers denote uncertainty intervals. The dashed whisker gives a range for the best estimate for Cirrus Clouds. The evaluation below the graph is a relative appraisal associated with each component and indicates the level of scientific understanding.

Figure 6-9: Radiative Imbalance at Tropopause



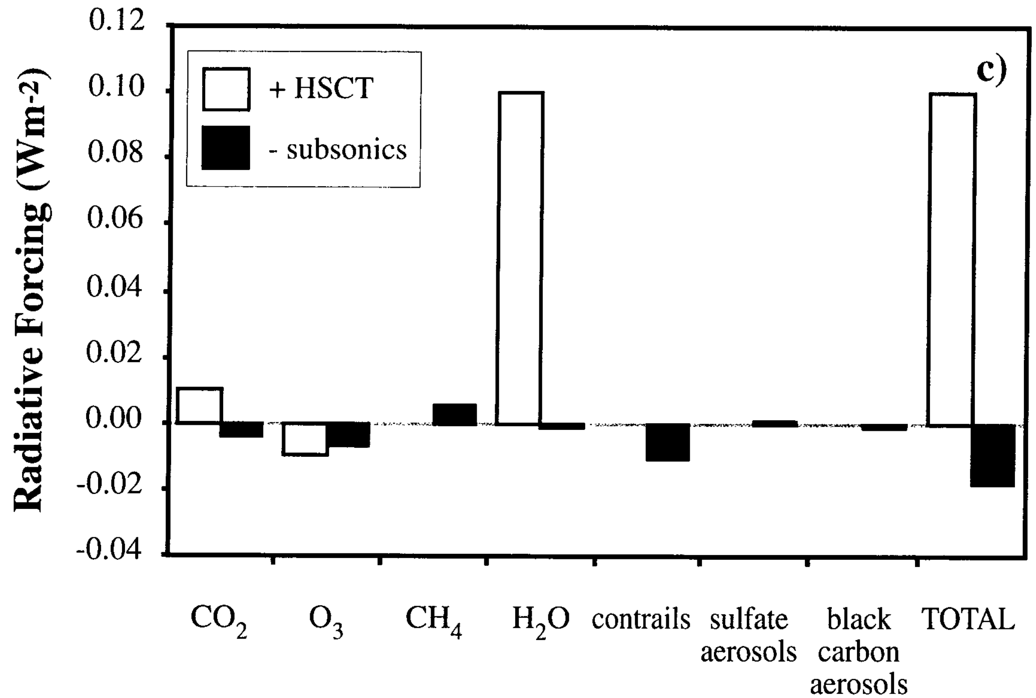
Zonal and annual mean radiative imbalance (Wm^{-2}) at the tropopause (after the adjustment of the stratospheric temperature) as function of latitude due air traffic for 1992.

Figure 6-15b: RF (Subsonic Aviation, 2050)



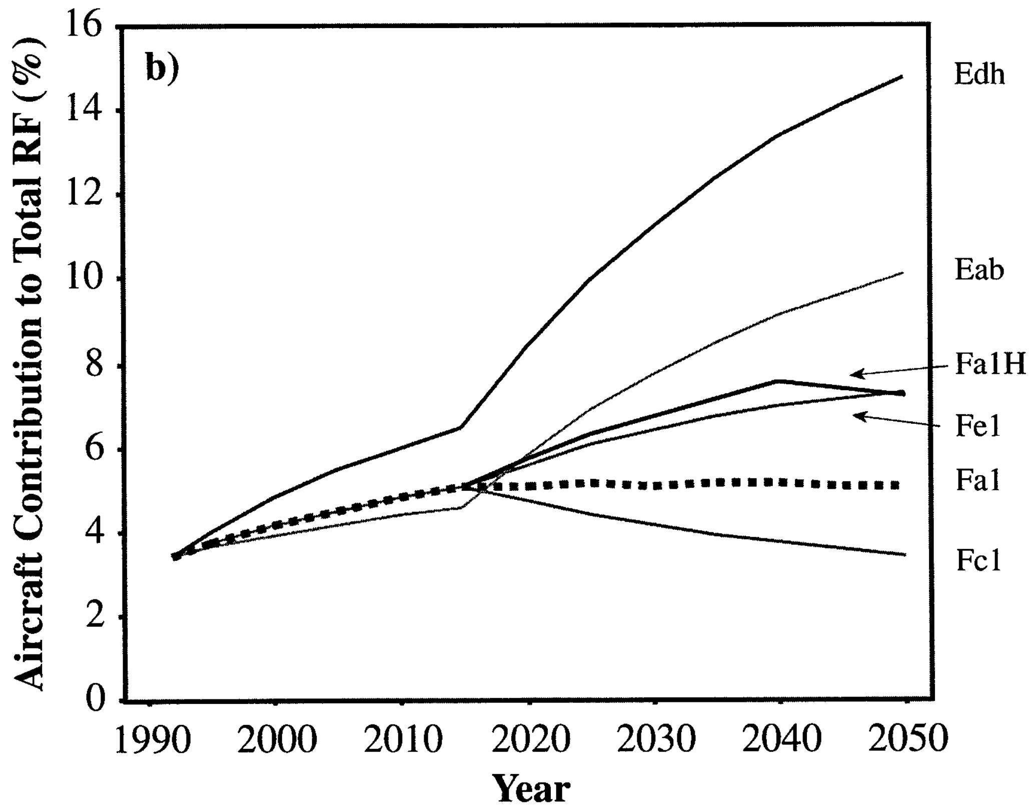
Bar charts of radiative forcing in 2050 from subsonic aviation (Fa1). The whiskers denote uncertainty intervals. The dashed whisker gives a range for the best estimate for Cirrus Clouds. The evaluation below the graph is a relative appraisal associated with each component and indicates the level of scientific understanding.

Figure 6-15c: RF (Supersonic Aviation, 2050)



Bar charts of radiative forcing in 2050 from the additional effect due to supersonic air traffic. Note scale change from (a) to (b) and (c). The white bars denote the direct effect of the supersonic fleet (HSCT1000) whereas the black bars display the change resulting from the displaced subsonic air traffic.

Figure 6-16b: Relative Aviation Radiative Forcing



Aviation radiative forcing relative to the IS92a fossil fuel use from 1990 to 2050 for the air traffic scenarios Fc1, Fa1, Fa1H, Fe1, Eab, Edh.

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Conclusions (1)

- In 1992 aircraft NO_x emissions have increased ozone concentrations at cruise altitudes in northern mid-latitudes by up to 6%.
- The ozone increase is projected to rise to about 13% by 2050 in scenario Fa1.
- The aircraft NOx emissions are expected to decrease the concentration of methane.
- In 1992, aircraft line-shaped contrails are estimated to over about 0.1% of the Earth's surface.
- The contrail cover is projected to grow to 0.5% by 2050 in scenario Fa1, at a rate which is faster than the rate of growth in aviation fuel consumption.

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Conclusions (2)

- Radiative forcing (RF) is used as metric of climate change.
- RF from CO_2, O_3 and contrails are of similar magnitude and positive, RF form CH_4 is of the same order of magnitude, but negative.
- Overall RF by aircraft is a factor of 2 to 4 larger than the RF by aircraft CO_2 alone.
- In 1992 RF by aircraft is 3.5% of the RF from all anthropogenic activity.
- In the standard scenario Fa1 RF grows by a factor of 3.8 until 2050. This corresponds to fraction of 5% of all anthropogenic RF according to IS92a.
- The RF of supersonic aircraft is larger (about 5 times) than the RF of the replaced subsonic aircraft.

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Conclusions (3)

- Additional aircraft positive RF may arise from aircraft-induced cirrus clouds.
- Some components of aircraft RF are geographically not homogeneously distributed (e.g. from O_3 and contrails), the resulting regional climate change may be larger and of different character than the global mean change

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UK MINISTRY OF DEFENCE USE OF OZONE DEPLETING SUBSTANCES – IMPLICATIONS OF THE NEW EUROPEAN COUNCIL REGULATION

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Ministry of Defence, St. Giles Court
1-3 St. Giles High Street
London WC2H 8LD, UK

Most of you will be familiar with the Montreal Protocol, which controls the production of the ozone depleting substances. These have been used extensively in fire protection and refrigeration in military equipment and systems. The implications of the Protocol for the military forces of NATO states were covered in LTSS/44, and the worthy conclusions and recommendations were reported in the opening sessions of the Symposium.

I wish to describe, initially, the current legislative position on ozone depleting substances within the European Union. I will then discuss the policies that the UK Ministry of Defence has in place, and the progress that has been made, so far, in reducing use of the substances. Of course, legislation continually evolves, and I will then summarise recent developments in the European Union, finally suggesting that NATO could, perhaps, play a valuable, more proactive, part in the development of new international environmental legislation.

Within Member States of the European Union, the Montreal Protocol is implemented by a European Council Regulation. The Regulations are proposed by the European Commission, and negotiated and agreed by the European Council of environment ministers from all the Member States.

Essentially, the current Regulation, dating from 1994, imposed production bans on the CFCs and halons, similar to those required under the Montreal Protocol. But potentially more significantly, it introduced use controls on HCFCs. These included the immediate banning of their use as fire extinguishants, and the banning of their use in the production of large-scale refrigeration equipment from the end of 1999. Individual Member States are able to introduce additional controls if they so wish, and a number of countries have done so. However, there is currently no other related legislation within the UK.

Ministry of Defence (MOD) policy on ozone depleting substances was established within this legislative framework. It was built on the premise that the legislation would continue to tighten, and that use of the materials could not continue indefinitely. Policies therefore go beyond the current legal requirements.

Ministers require that MOD does not install any new applications of the ozone depleting substances, and does not use the materials in any new designs of equipment. In all existing uses, emissions are to be minimised and the materials are to be replaced wherever it is technically and economically feasible to do so.

Applications for which no alternatives are feasible are classed as MOD Essential Uses. They are supported from a central Bank of recycled materials – users themselves cannot buy the substances. This approach is intended to secure the supply of the materials for as long as needed, whilst retaining tight control on which applications are allowed to continue. The MOD's Essential Uses of CFCs and halons are largely in front-line equipment. Examples include CFC refrigeration and halon fire protection systems on ships and submarines, in aircraft and armoured vehicles, and in a few command and control centres and research facilities. The list of Essential Uses is regularly reviewed and the users must regularly re-assess the feasibility of conversion of their equipment.

Paper presented at the RTO SAS Symposium on "Approaches to the Implementation of Environment Pollution Prevention Technologies at Military Bases", held in Budapest, Hungary, 5-7 May 1999, and published in RTO MP-39.

Good progress in the replacement of the substances has been made in several areas, particularly in the CFC refrigeration applications. Trials of hydrofluorocarbon (HFC) alternatives have shown them to be acceptable in many applications, with modifications to equipment being relatively minor. In other circumstances, equipment has been replaced with new plant. The Royal Navy, for example, historically the largest MOD user of CFCs, has reduced its installed capacity of CFC-12 by over 80% since 1994. Technical difficulties with the conversion of halon and refrigeration systems in armoured vehicles have been solved and conversion programmes started. Halon systems in many buildings have been, and continue to be, replaced.

Generally, in these cases, CFCs are being replaced by pure HFC refrigerants, normally HFC-134a, or blends containing them. The halons are being replaced by a mixture of traditional extinguishants, such as carbon dioxide or sprinklers, the newer inert gases such as Inergen™, or HFC extinguishants such as FM200™.

But, as reported in the LTSS/44 study, there are a number of important applications where use of recycled ozone depleting substances will still be necessary for some time to come. For example, suitable alternatives to CFCs in existing submarines have only recently been confirmed as suitable, because of toxicity issues and concerns about their performance and their compatibility with air purification equipment. The necessary modifications to the equipment can only take place during planned ship refits and programmes will therefore take a number of years to complete.

Suitable alternatives to the halons in current ships, submarines and aircraft have not yet been found. Unless better options become available, they will most likely have to continue in use for the remaining life of the equipment.

Another particular difficulty concerns the replacement of halon 1211 in some portable extinguishers. Whilst the extinguishers can be replaced with traditional alternatives in the vast majority of cases, they are still necessary in aircraft and armoured vehicles. In these situations, occupants need a safe and effective extinguishant that will not obstruct them in the performance of their duties.

In most of the remaining Essential Uses of the halons, replacements have not been identified for one or more reasons. Normally, the available options do not perform well enough; or they are too toxic in use, or they possess unsuitable physical or chemical characteristics. But work continues to find and evaluate potential solutions.

Last Summer, the European Commission proposed a new Regulation on ozone depleting substances. It was based on the assumption that alternatives were readily available for nearly all the applications of CFCs and halons. Consequently, the Commission advocated a significant tightening of controls, including use controls on the CFCs and halons for the first time.

For example, it was proposed that use of CFCs, including recycled CFCs, in the maintenance and refilling of refrigeration systems, should be banned from the end of 1999. No exemptions were considered to be necessary. It was also proposed that all use of the halons, including recycled halons, to refill or top-up fire protection systems would be banned from the end of 2003. The Commission did recognise that not all the halon uses could be replaced. A limited number of Critical Use exemptions were envisaged, for aircraft, military vehicle crew compartments, and the inerting of occupied spaces where flammable liquid release may occur. Only the halon portables used on aircraft, and by military and police forces “on persons”, were considered to be critical.

It was quickly appreciated that the MOD could not possibly comply totally with such a proposal. Even if it might be possible to install alternatives within the time-scales specified, any of the available options would result in an unacceptable reduction in the safety of personnel and the performance of the systems. If these risks were to be accepted, most front-line equipment would then have to be called in for modifications, at enormous cost. Finally, it was expected that the

capacity of the UK defence industry would be inadequate to complete the necessary work in time. Even with the best efforts, operational capability of UK forces would have been unacceptably compromised.

Any decision to maintain operational capability and not comply with the environmental legislation would undoubtedly be a politically sensitive one.

So the MOD became actively involved in negotiations, through the UK Department of the Environment, Transport and the Regions. We managed to convince the UK negotiators that the proposal would cause insurmountable difficulties. It was agreed that the UK would attempt to negotiate a deferral of the CFC use ban to give all users (not just the military) more time to convert. The UK would also seek some form of flexible exemption mechanism for the halons and CFCs used by the military sector and other "critical users" in industry.

During early negotiations, these suggestions met with no support at all from other European Union Member States. None could see that the UK would face any real difficulties in replacing all its remaining uses of CFCs within a year or so. The UK negotiating team modified its position several times, initially agreeing to the principle of a fixed list of halon critical uses, but suggesting, with a number of other countries, a few additional applications. But there was, for some time, still no support for any exemptions to the CFC use ban.

However, in the steady progress towards a compromise Regulation to which all Member States could agree, the UK delegation managed to gain the most important changes sought by the MOD. The CFC use ban was deferred until the end of 2000, with the possibility of military exemptions from then until the end of 2008. Any such exemptions will be considered and authorised by the European Commission on a case by case basis. The list of halon Critical Uses was expanded to cover the most important remaining military applications, including halon 1301 in occupied spaces and engine compartments of military vehicles and naval vessels and in occupied military communication and command centres, and halon 1211 in aircraft engines, cargo and dry bays. But the legislation was rushed through so quickly that exactly what is and is not covered is not really clear. A few technical issues were not resolved, and still have to be clarified.

Several changes agreed during the negotiations went against the interests of remaining users. There was a further tightening of some of the use controls. For example, the halon use ban was brought forward to the end of 2002 – some negotiators wanted to bring it forward to 2000, the same as for the CFCs. It was also agreed that non-critical halon systems must be decommissioned by the end of 2003, so users do not have the option of retaining their systems for "once only" protection.

A few minor changes to the list of halon Critical Uses need to be argued during the annual review process. Otherwise, MOD will be forced to convert some of its halon 1211 systems, in aircraft and military vehicles for example, to halon 1301. Since the latter has a much higher ozone depletion potential, the argument for the changes would seem to be convincing, but it is still to be made and accepted.

It is important to note that, at this time, the European Parliament has yet to evaluate and approve the version of the text agreed by the Council of Ministers. Historically, the Parliament is notably greener than the other organisations, and it may yet be necessary to defend the hard-won concessions described here. Only when the Parliament and Council have both agreed the text will the Regulation be adopted and come into effect.

A number of lessons have been learnt during the processes so far that will lead to the new Regulation. It seems to be very difficult for an individual defence ministry to act effectively to influence the development of environmental legislation in Europe.

Those who draft and negotiate the legislation are often not sufficiently aware of the detailed environmental implications and technological complexities of maintaining military capability. With one or two exceptions, good links between the relevant ministries do not seem to have been forged or maintained.

Yet the legislators are exposed to organised lobbying from interest groups in industry and the environmental movement. These interests are not necessarily compatible with those of the military. In this case, they were clearly against the interests of the UK Ministry of Defence and other responsible users of the ozone depleting substances. In the end, the measures in this environmental legislation seem to have been defined more by economic and trade concerns. Arguably, the ozone layer could be better protected, with a range of measures to ensure the responsible management of the phase out of the remaining uses of the substances. Instead, blanket bans on usage will almost certainly be introduced without enough consideration of how to ensure that the unwanted materials are safely collected, or what to do with them then, or who might pay for their destruction. Unless these issues are resolved quickly by all the Member States, significant emissions of the gases may result in the near future.

To try to prevent some of these problems from occurring again, I feel strongly that there is a need for NATO Defence ministries to act more closely together on environmental matters, and particularly during the development of new international legislation. It is especially important to liaise with and inform those in the European Commission who draft the legislation. At the drafting stage, there is opportunity for detailed discussion of issues such as technical and economic feasibility, and the impact of possible measures on military organisations and on the environment. Afterwards, during negotiations, there is much less opportunity to argue for substantial changes in the philosophy or approach of any proposal, should they be thought necessary or desirable. Reasoned arguments tend to be ignored or forgotten in the drive towards an acceptable political compromise.

I think there would be much to gain from a single NATO focus for co-ordinating NATO Member States' activities on environmental issues, and for representing the interests and concerns of the militaries at both the European and international level. NATO should take a more proactive role in the development of legislation. It should also ensure that legislators and the public appreciate the positive attitude that now exists towards environmental protection in military organisations, and the range of skills and expertise that exists. It should emphasise the significant investment and progress that have been made, and continue to be made, across the full range of environmental protection issues. But it should also ensure that legislators are aware of the genuine difficulties that some military organisations face, particularly with respect to legacy issues.

Precisely how this NATO focus might be established, I do not know. But I would like to see some form of permanent environment committee, drawn from member states, and ideally supported by a NATO technical and policy secretariat.

The benefits might be numerous. It could easily be argued, for example, that:

Military interests would be more effectively represented;

Information and experiences would be more effectively shared between states;

Environment-related research activities would be better focussed and co-ordinated;

Interoperability would be enhanced;

Impact of NATO forces on the environment would be reduced;

Costs and impact of compliance efforts would be reduced;

Better legislation would result.

But there is also no time to waste. There are a number of important environmental legislative initiatives that are gathering momentum. To give just one example, although it is probably the most significant one, there is the Kyoto Protocol. This has established legally binding limits on the emissions of the main greenhouse gases, which include the hydrofluorocarbon gases now being adopted as replacements for the halons and CFCs.

Although there are no specific controls on HFCs mentioned in the Kyoto Protocol, each signatory country must consider a range of options if it is to reduce its emissions of these greenhouse gases. Use controls are a very obvious option.

Since most military organisations are beginning to rely on the HFCs in particular, in a number of applications, simply because no other acceptable options exist, the military perspective needs to be brought to the attention of those involved in the legislative processes. This is being done to some extent though the relevant expert committees, by individuals and single countries acting alone, but the concerns, suitably focussed and co-ordinated, need also be taken straight to the environmental legislators themselves. Undoubtedly, NATO could, and should, play an important part in this activity.

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The Storage of POL and Chemicals in Packaging in the Royal Netherlands Army

by

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Introduction

1. In the ninety eighties a chemical storage facility of Sandoz inc. in Basel suffered a major fire. During this disaster tons of toxic chemicals polluted the river Rhine severely. As a direct result of this disaster, the Netherlands Government introduced new environmental legislation on the storage of POL and chemicals in packaging. This legislation makes a distinction between a facility with a storage capacity of no more than 10 tons of POL and chemicals in packaging (Regulation CPR 15-1) and a facility with a storage capacity of more than 10 tons of POL and chemicals in packaging (Regulation CPR 15-2). If a major accident happens in a CPR 15-2 facility far more than 10 tons of chemicals are involved. As a consequence, requirements for a CPR 15-2 storage facility are much more severe than the requirements for a CPR 15-1 storage facility. Therefor, a CPR 15-2 storage facility is far more expensive.

2. During the Sandoz-fire, all kinds of chemicals reacted in a uncontrolled way with each other. This caused additional risk to the environment. In order to prevent this happening in the future, both CPR 15-1 and CPR 15-2 regulations require the separate storage of chemicals, which can react dangerously with each other.

3. In 1991 the Royal Netherlands Army introduced Environmental Care. As part of this scheme, several storage facilities for POL and chemicals were checked against these new regulations. The findings were:

a. Chemicals which can react dangerously with each other, were not stored in separate compartments, as required by both CPR 15-1 and CPR 15-2 regulations; The average soldier had no idea, which chemical has to be separated from which;
b. There was no confidence in the logistics. Besides, every unit within the Army was licensed to order goods from the central Army-depots. As a result, every user within the Army had ample stores of POL and chemicals. At one barracks stores sufficient for one and three quarter years of maintenance were discovered;
c. The storage facilities didn't meet the new requirements as formulated in CPR 15-1 or CPR 15-2;
d. As a consequence of the high level of stock, many Army barracks required a new storage facility accordingly to CPR 15-2.

4. The Commander in chief of the Army ordered an efficient and cost-effective solution for all the above problems.

Storage of chemicals in separate compartments

5. The CPR 15-1 and CPR 15-2 require that, and I quote:

> "Chemicals which can react with each other in the course of which dangerous vapours can arise, explosions can occur or drops of chemical product can splash around, should be stored in separate compartments".

6. At least oxidising-, inflammable-, poisonous- and corrosive chemicals have to be stored in separate compartments. Further more, bases have to be separated from acids, acids from cyanide etc. Where as the Army had to comply to this regulation, it had the option to give every user an extensive chemical training or give him unequivocal instructions. For practical reasons, the Army choose the last option.

Paper presented at the RTO SAS Symposium on "Approaches to the Implementation of Environment Pollution Prevention Technologies at Military Bases", held in Budapest, Hungary, 5-7 May 1999, and published in RTO MP-39.

7. In order to solve develop unequivocal instructions, the Army looked at the types of chemicals it uses. These types are:

   a. flammable liquids;
   b. flammable solids;
   c. oxidising chemicals;
   d. toxic chemicals;
   e. bases;
   f. acids;
   g. oil and lubricants.

8. Furthermore the Army looked at the European regulations on the transport of dangerous goods by road, the so called ADR-regulations. ADR gives clear criteria, how to classify a product as one of the above types of chemicals. The criteria can be found in the following marginal numbers:

a. flammable liquids	marginal number 2300;
b. flammable solids	marginal number 2400;
c. oxidising chemicals	marginal number 2500;
d. toxic chemicals	marginal number 2600;
e. corrosives (acids and bases)	marginal number 2800.

9. For instance the criteria for inflammable liquids are:

letter (a):	Very dangerous substances; flammable liquids having a boiling point or initial boiling point not exceeding 35 °C, and flammable liquids having a flash-point below 21 °C, which are either highly toxic according to the criteria of marginal 2600 or highly corrosive according to the criteria of marginal 2800;
letter (b):	Dangerous substances; flammable liquids having a flash-point below 21°C which are not classified under letter a), with the exception of substances of marginal 2301, 5°(c);
letter (c):	Substances presenting a minor danger: flammable liquids having a flash-point of 21 °C up to 61 °C and substances of marginal 2301, 5°(c).

10. Although the CPR-regulations claim that chemicals can cause no more than one risk, ADR disagrees and gives clear criteria, which risk prevails the other. For example: Methanol, UN number 1230is flammable and toxic. Accordingly to the marginal 2300 and 2600 of ADR, the risk of flammability prevails the risk of toxicity. Methanol therefor is a chemical of ADR class 3. Therefor, the Army decided to adopt the criteria of ADR. Where as most of the chemicals the Army uses fell within the criteria of the ADR regulations, the Army translated them into so called "Storage codes". These day's the Army uses the following storage codes:

Schedule 1. Storage codes used by the Dutch Army.

Storage code	Risk	Criteria
1	**Flammable chemicals**	**Spraying cans of the ADR-class 2, 5F, Flammable liquids with a flash point of less than 100 *C (mostly chemicals of the ADR-class 3, Flammable solids of the ADR-class 4.1**
2	**Toxic chemicals**	**Chemicals, which can cause a risk to the health, mostly chemicals of ADR-class 6.1**
3	**Oxidising chemicals**	**These are chemicals of the ADR-class 5.1 and 5.2**
4	**Acids**	**These are mostly chemicals of the ADR-class 8, digit 1 till 40**
5	**Bases**	**These are mostly chemicals of the ADR-class 8, digit 40 till 56**
6	**Risk to the soil**	**Chemicals, not classified under the storage codes 1 till 5, who cause a risk to the environment, when spilled onto the soil**
N	**No known risk**	**Chemicals, who cause no risk to the environment or the user**

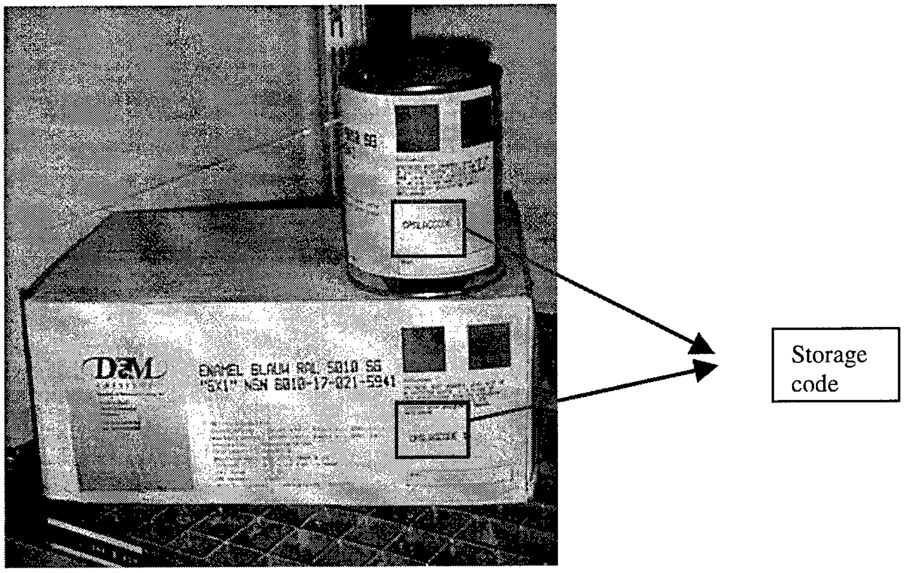

Photo 1. Example of a storage code on a packaging

11. In order to make it easier for the user, every packaging carries a storage code. In schedule 2, the user can reed, which storage codes may be stored together in one and the same storage compartment.

Schedule 2. Storage codes that may not be stored together in one storage compartment

Storage code	1	2	3	4	5	6
1		x	x			
2	x		x	x	x	x
3	x	x		x	x	x
4		x	x		x	
5		x	x	x		
6		x	x			

x = may not be stored together in one storage compartment.

Conclusion.

12. If the user stores chemicals accordingly to schedule 2, he complies to the regulation of separate storage.

Reorganising the logistics.

13. As mentioned in the introduction, due to no confidence in the logistics, many Army-units had far to much POL and chemicals in stock. If this situation was not altered, the Army had to invest far to much in new storage facilities. In order to minimise the necessary investments in storage facilities, the Army made the following decisions:

   a. The user of POL and chemicals in a workshop only has stock for roughly 1 day of use. In practice, per product the user has one packaging in use. At the most, he has one spare packaging in stock; In practice, the stock hardly exceeds 150 kg of chemicals and 1000 kg of oil and lubricants; The user can replenish his stock daily.
   b. Every barracks has one local POL and chemicals depot. In total, the Army has approximately 50 local depots. The user orders the necessary POL and chemicals at a daily base at his local depot. Every local

depot has an average stock, sufficient for 14 days of normal use; In practice, the stock hardly exceeds 2500 kg of chemicals and 2500 kg of oil and lubricants; Once or twice a week, the local depot receives new stock;

c. One central Army depot supplies its countrywide situated customers with POL and chemicals. The depot has sufficient stock for 3 to maximum 10 months of use. The central depot has space for 5000 pallets (approximately 2500 tons of chemicals and POL). The central depot guarantees a customer satisfaction of 98 %.

Conclusion

14. By reorganising the logistics, the Army was able to:

a. Restore confidence in the logistics;
b. Reduce the level of stock substantially;

Storage facilities accordingly to CPR 15-1 and CPR 15-2

15. Regulation CPR 15-1 gives the user the following possibilities to store POL and chemicals in packaging.

Schedule 3. Storage of POL and chemicals in accordance to CPR 15-1.

Storage facility	Storage of	Maximum storage capacity	Particulars
Retention basin	storage code 6	400 litres	
Removable hazardous materials depot	storage code 1 to 6	150 litres	■ store each storage code on one separate shelf ■ depot is 30 minutes fire resistant ■ depot has a retention basin with 100 % product storage capacity
Hazardous materials depot in a building	storage code 1 to 6	2500 litre	■ store each storage code accordingly to schedule 2 ■ walls of the depot are 60 minutes fire resistant ■ door and roof of the depot are 30 minutes fire resistant ■ depot has a retention basin with a product storage capacity of 100 % (storage code 1) and 10 % (storage code 2 to 6)
Separate hazardous materials depot, not connected to an other building	storage code 1 to 6	10.000 litres	■ store each storage code accordingly to schedule 2 ■ walls of the depot are 60 minutes fire resistant (distance to other building minimal 5 meters) ■ door and roof of the depot are 30 minutes fire resistant ■ depot has a retention basin with a product storage capacity of 100 % (storage code 1) and 10 % (storage code 2 to 6)

Photo 2. Retention basin for environmental goods (storage capacity: maximal 400 litre)

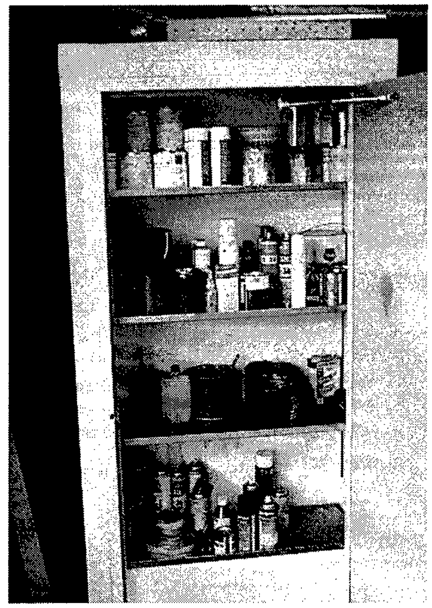

Photo 3. Removable hazardous depot (storage capacity: maximal 150 litre)

16. Regulation CPR 15-2 gives the user the user many possibilities to store POL and chemicals;
    - store each storage code in a separate compartment;
    - depot has a automatic fire detection system;
    - depot has a retention basin with a product storage capacity of 25 % (depot has an automatic fire fighting system) to 100 % (depot has no automatic fire fighting system);
    - depot also has a retention basin to store water used to extinguish a fire, the capacity may range from 1 m3/m2 surface (with a minimum of 300 m3) to 16 m3, depending on the method of fire fighting;
    - walls and doors of the depot are 60 minutes fire resistant;
    - roof of the depot is 30 minutes fire resistant.

17. The Dutch Army evaluated all the options and has chosen to build a depot with a automatic carbon dioxide fire fighting system. As a result, the depot only needs a retention basin with a product storage capacity of 25 % (150 m3) and 16 m3 of fire fighting water.

18. The average investment to upgrade the storage facilities are:

■ User in workshop	Approximately USD 2.500,00
■ Local depot	USD 25.000,00 (upgrading existing storage facility) to USD 150.000,00 (new storage facility)
■ Central Depot	USD 6.000.000,00 (new CPR 15-2 facility)

<u>Conclusion</u>

19. Due to the reorganisation of the logistics, the Army was able to control the investment in upgrading and building new storage facilities.

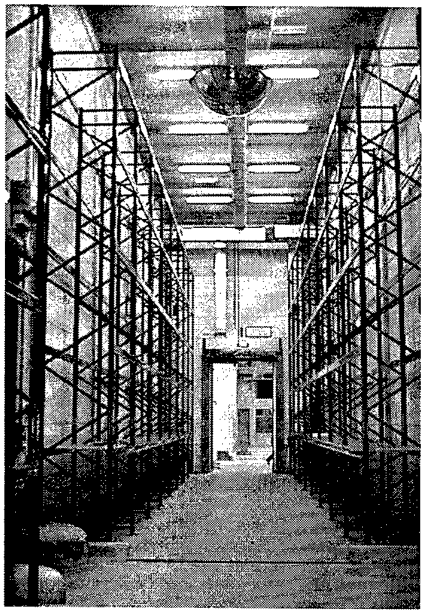

Photo 4. One of 20 compartments with space for 192 pallets

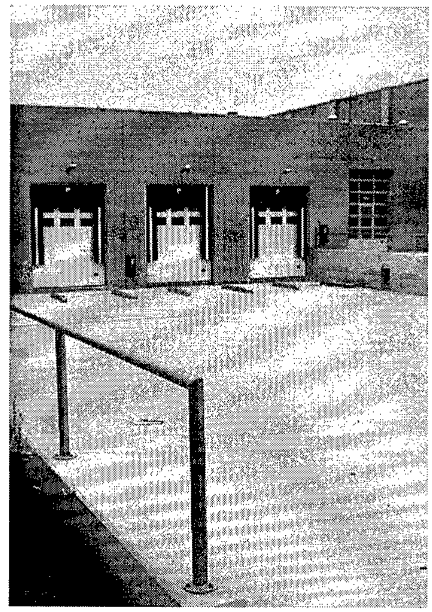

Photo 5. Loading dock, can be used as a retention basin

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National Supply Agency

**STORAGE of POL and CHEMICALS in PACKAGING
in the**

ROYAL NETHERLANDS ARMY

May 5 - 7 Budapest , Hungary

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National Supply Agency

In 1991, the chemicals/POL - storage facilities were checked against new Dutch Environmental & Safety legislation

The conclusions were:

- No separate storage of chemicals that can react dangerously with each other
- No confidence in new army-logistics, resulting in high levels of stock
- Storage facilities didn't meet new environmental requirements

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National Supply Agency

Storage of POL and Chemicals in separate compartments

Chemicals which can react with each other in the course of which risks to the environment or health can arise, have to be stored in separate compartments of a storage facility

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Storage code	Description
1	Flammable solids and liquids (FP<100°C)
2	Poisonous chemicals
3	Oxidising chemicals
4	Acids
5	Bases
6	POL/Chemicals which may cause soil-pollution
N	No risks

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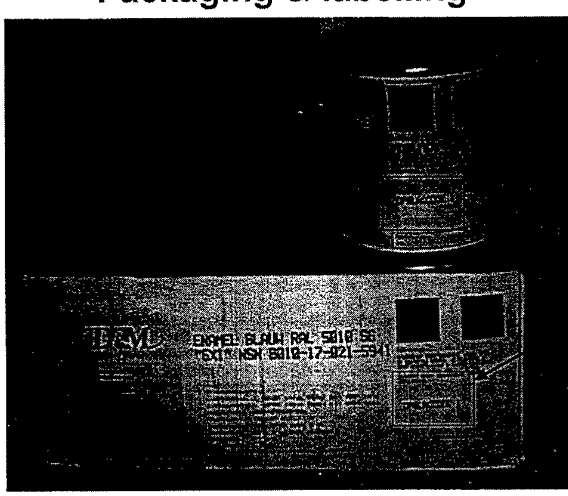
National Supply Agency

Packaging & labelling



storage
code

Example of storage code on a can and case

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Reorganising the LOGISTICS

- Users in workshops (±1000)	stock for 1 day
- Local POL/chemical depots (±50)	stock for 14 days
- Central Depot (1)	stock for 3-10 months

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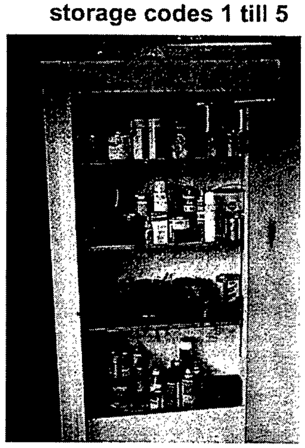
Average storage facility in a workshop for the storage of POL/chemicals of storage codes 1 till 5



Removable hazardous materials depot
(capacity : max 150 kg)

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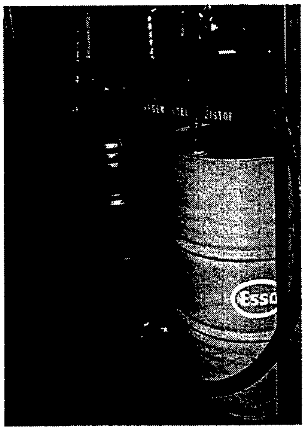
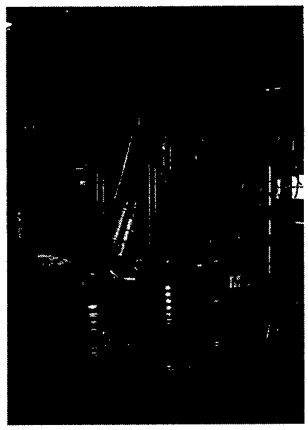
Average storage facility in a workshop for the storage of Oil and Lubricants of storage codes 6





Retention basin for environmental goods
(capacity : max 400 kg)

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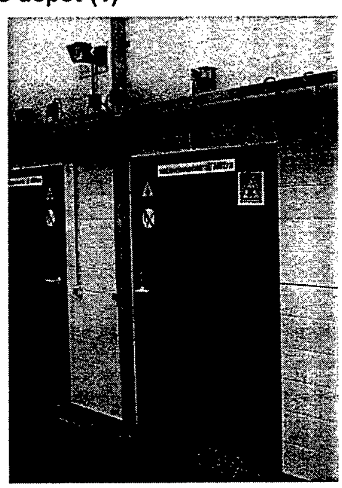
Average local POL and Chemicals depot (1)

Retention basin for storage code 6



Storage compartment

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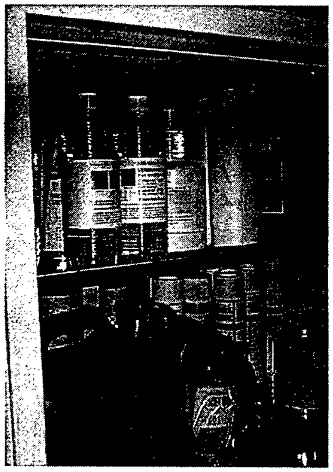
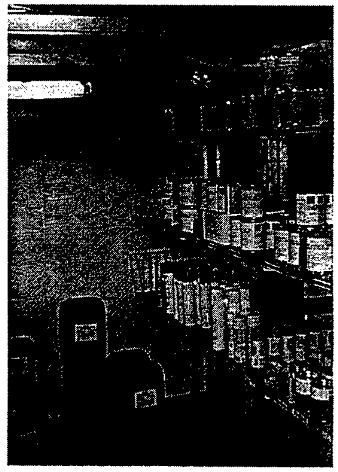
Average local POL and Chemicals depot (2)





Contents of a separate storage compartment

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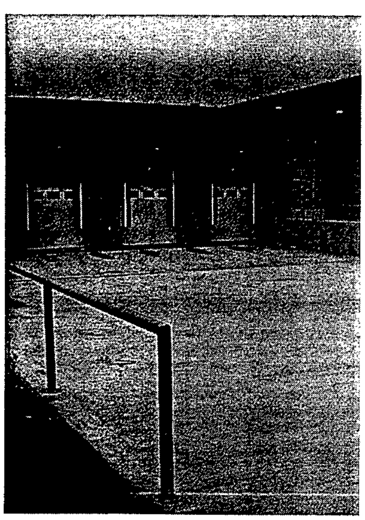
New Central Army POL and Chemicals depot (1)



Loading dock

In case of an accident, the loading dock can be used as a retention basin

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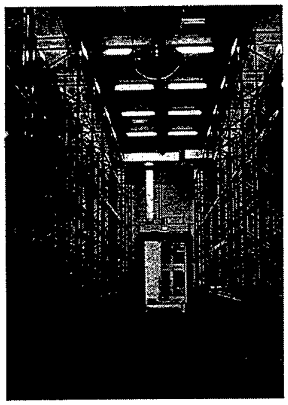
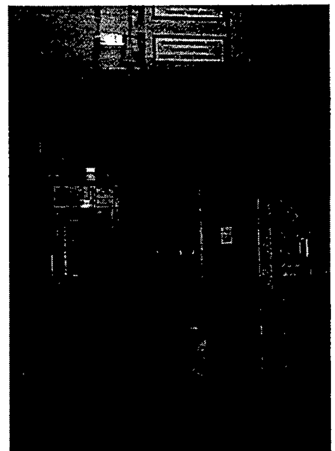
New Central Army POL and Chemicals depot (2)



One of twenty compartments
with space for 192 pallets



Fire door

Site Contamination Problems in the Republic of Latvia: Ongoing Clean-up Activities and Future Pollution Prevention Plans

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Today the problem of site pollution in the Republic of Latvia is becoming more and more important not only as an environmental problem, but also as one, which hinders the growth of economics because it creates difficulties for investments.

In the Environmental Policy Plan of Latvia, officially approved in 1995, the site pollution problem was not identified as the first priority. At that period such issues as drinking water supply & wastewater treatment, waste management and air pollution problems were considered as more urgent.

Presently situation has changed and site contamination problem is one of those which needs be solved within the near future.

Activities already curried out have indicated a lot of difficulties in this area. One of the main among them is related with the fact that Latvia (similar as other Baltic Countries) has enormous amount of old contaminated sites left as a heritage by former Soviet System. This makes situation very specific as it is almost impossible to use the principle "Polluter pays", which step by step is becoming the main approach in a solution of current environmental problems in Latvia. In this case the polluter is well known but it will never pay, especially if it is former Soviet Army. It means that there is need to find out specific ways how to solve this problem. This creates huge economical and juridical difficulties. From one side the State does not have resources for clean-up activities. From other side most of landowners, which have received their properties in the result of denationalization and privatization processes, also do not have enough resources. Lack of rules how to deal with pollution on these lands create problems both as for local landowners as well as for international investors who is interested to run their business in some of former military sites such as naval bases, airfields, different reparation plants etc. This is also a huge problem for the Latvian Armed Forces as our military units mainly are stationed in former Russian military bases.

At the present moment policy makers in Latvia still have not exactly defined the main approaches for solution of polluted military sites problem, but it is more likely that site remediation predominantly will make a part of normal commercial redevelopment of land with funding considered at the level of individual site, than being a part of a specific overall national environmental improvement programme. The process could start with the sites having a very high level of risk to human health and environment.

Therefore the most urgent task is to set up a legal base for contaminated sites management and pollution prevention. This process is under active development now. The special law - Law on Pollution Control is in a stage of drafting and the first draft of the main chapters just is reviewed.

The main functions of the chapter "Contaminated Areas" are to:

- provide for inventory and registration of contaminated and potentially contaminated areas in Latvia;
- determine general preconditions for information, investigation and remediation measures in connection with contaminated and potentially contaminated areas;
- determine the financial liability for investigation and remediation measures;
- provide the necessary legal instruments for State institutions to conduct and administer investigations and remeaditions.

According to the accepted plan this law should be approved by Parliament till middle of the next year.

Some progress is achieved also regarding such practical activities as assessment, investigations and clean up of contaminated sites.

Paper presented at the RTO SAS Symposium on "Approaches to the Implementation of Environment Pollution Prevention Technologies at Military Bases", held in Budapest, Hungary, 5-7 May 1999, and published in RTO MP-39.

First of all it is necessary to mention that today the ecological assessment of former military sites in Latvia are carried out according to one set of methods, worked out within the scope of work of Latvian - Norwegian cooperation project. The experts of the Latvian and Norwegian Geological Surveys assessed and investigated more then 600 former Soviet military sites, 255 of which were incorporated in special computerized database. The database was established using MS ACCESS software. The database contains all information collected during the studies of former military sites.

The Latvian and Norwegian specialists developed criteria, based on which all sites have been subdivided into 4 groups:

I group – sites, in which it is evident that site is polluted with hazardous substances and poisons spread into the environment or sites contaminated with explosives which all together could cause essential threat to human life and to the environment, detailed investigations and clean-up activities are urgent;

II group – sites regarding which there is only some information about pollution of the site with hazardous substances which could cause threat to human life and to the environment, further site investigations are required;

III group – sites, where pollution of site is insignificant and possibility of migration of hazardous substances also is unessential, site investigations are required only in case of change of land use;

IV group – sites where there is no evidence of pollution and hazardous materials, further site investigations are not required.

According to the mentioned criteria 255 main former military sites were assessed and result was follows:

- in I group – 14 sites;
- in II group – 17 sites;
- in III group – 62 sites;
- in IV group – 171 sites.

The most dangerous for human health and the environment is I group which consists of 7 former rocket bases, 2 big fuel stations, 1 very large bombing range, 1 ammunition storage site, 1 airfield, 1 tank reparation plant and 1 submarine base in former Liepaja Naval Base.

Petroleum pollution of the soil was found to be the most widespread of all the problems resulting from the Soviet Army's activities. The most polluted petroleum areas were found where fuel and lubricants were pumped, stored, and transported and where transport and combat materials were washed, especially after accidental spills. Almost in all detailed investigated fuel storage sites free phase oil has been found.

Another very serious problem is unexploded ordnance in former bombing ranges and ammunition storage sites (especially if explosives are deep in soil).

Detailed pollution investigations are carried out only in some of military sites, and mainly it has been done with assistance of our donor countries (Denmark, Norway, Germany, Canada as well as USA and Sweden). Here we can mention:

- the investigations of Lievarde and Rumbula airfields (with assistance of Germany and Denmark),
- the investigation and remediation pilot project of rocket base in Liepaja district (in cooperation with Canada),
- the investigations of fuel base and site of former tank reparation plant in Riga (in cooperation with Norway),
- ongoing activities in Adazi training field (cooperation with USA and Sweden),
- Liepaja Harbour Environmental Study (Phare Programme with participation of Danish specialists),
- planned activities in the area of former Liepaja Naval Base - Liepaja Karosta district (in cooperation with Canada).

Up to now clean-up activities are carried out only in some of very harmful sites. Mainly those are pilot projects with purpose to find the best clean-up technologies and to prevent the spreading of hazardous substances to drinking water reservoirs and ambient surface water bodies. Such activities are carried out in the former Rumbul Airbase in Riga and in the Barta Missile Base in Liepaja district.

The former Rumbula Base is located in the southern part of Riga between the Riga–Daugavpils Highway and the Daugava River approximately 15 km from Riga Centrum. The airbase covers an area of approximately 3.0 km^2. Rumbula Airbase operated as a military base from 1954 until 1978.

The primary objective of the Rumbula Airbase project was the clean-up of the pollution remained after Soviet military activities and the preventing from oil spreading into drinking water reservoirs and the Daugava River. Depth to ground water at the base averages 2.3 m below ground surface, and ground water flow direction beneath the site is south to south-easterly, toward to the Daugava River.

There are identified four areas where ground waters are polluted with dissolved oil product contaminants (200 ha or approximately ½ of Rumbula Airbase area) and six areas with free phase aviation fuel (in total approximately 10 ha). Thickness of free phase product in different places was found of 0.2 to 1.0 m. Soil pollution mainly tied to areas of free phase products in zones of seasonal fluctuation of the groundwater level.

The Rumbula Airbase project still is in progress. In 1998 there were carried out the technical investigations with purpose to find the most efficient and cost-effective technologies for recovery of free phase aviation fuel (skimming, pumping and vacuum enhance). Latvian company Baltec Associates, SIA and Danish company Hedeselskabet participate in these investigations in the area of former Rumbula Airbase. Latvian Government, Danish EPA and Riga Municipality fund the activities mentioned above.

The former Barta Military Base is situated in western Latvia. This former missile base was abandoned in the fall of 1994.

Riga Technical University, Canada-Emergencies Engineering Division and Gartner Lee International Inc. have conducted an environmental assessment at this base. Initial assessment activities identified a site where reportedly 11 tons of "SAMIN" missile fuel has been spilled. Xylidine (aminodimethylbenzene) is the pollutant of concern in the "SAMIN" spill. The assessment activities identified a 0.5 m layer of free-product floating on the shallow water table over an area of at least 800 m^2.

In a field remediation demonstration conducted in 1996, ex-situ land farming was evaluated for treating xylidine-impacted soil. The xylidines analysis from the control plot indicates that approximately 60% of the initial concentration of xylidines was lost by volatilisation, leaching or intrinsic biological processes. These results demonstrated that land farming, as one of the most cost-effective methods for treatment of contaminated soil, could be the most feasible remedial option for treating contaminated soil at the Barta Military Base and in other similar sites.

It is very important to take care about the former military sites, but at the same time it is also significant to prevent contamination of those sites occupied by Latvian Armed Forces. It means, on the one hand there is need to organise military training and manage the military facilities in an environmentally sound manner, on the other hand it is necessary to deal also with historical pollution left by foreign armies as Latvian military units mainly are stationed in former Russian military bases.

Latvian Ministry of Defence and Ministry of Environmental Protection and Regional Development have started to incorporate environmentally sound approaches in practice of military training. Project – so named the Environmental Security Project initiated by USA Sweden is a very important support within these undertakings. The main purpose of this project is:

- to strengthen the co-operation and co-ordination between military and civilian organisations;
- to train the military personnel in the environmental management and to prevent further degradation.

In framework of this project the Latvian, US and Swedish military and environment officials agreed about co-operation in order to develop the Environmental Base Management Plan for Adazi Military Training Base. The Management plan will serve as pilot project and will:

- establish objectives and develop procedures to achieve sound environmental management;
- determine the level of environmental training necessary for personnel at various stages of command;
- set priorities and monitor clean-up activities that must take place in order to ensure the continued operations of the base;
- initiate activities aimed at preventing further environmental damage or pollution, wastewater treatment, hazardous waste management, land management for control of erosion and protection of rare and endangered species.

The Adazi Military Training Base is situated in Riga District, approximately 15 km to the north-east from Riga City border and about 30 km from Riga Centrum.

Latvian Army has used the Adazi Military Training Area for infantry training and as an area for artillery range in years 1930-1940. During Soviet times there was a training area that was used as training ground (also for shooting) for motorised infantry and tank regiment commanders as well as specialists of tank, artillery and auto units. The Latvian Ministry of Defence took charge of Adazi base from the Russian militaries in 1995, and the Adazi Training Centre was established. There are barracks, driving range, maintenance shop for vehicles and field practice. Currently area of training range is about 4500 hectares. Today the National Armed Forces and BALTBAT use the Adazi Training Centre as training ground for driving, light shooting and co-ordinated practice between different units and countries.

At present moment the Adazi project is in an active investigation stage and main activities are run in three direction investigation of pollution of ground and water media of the Adazi Military Training Base (Latvian consulting company "Geo Consultants");
evaluation for rare and endangered species (consultants from Latvian Fund for Nature);
inventory of infrastructure objects in the Adazi Training Base (specialists from Swedish and Latvian MoD).

It is planed to finish the project at the end of 1999. The Environmental Base Management Plan will developed within the scope of work of this project will contain all the basic information about the Adazi Military Training Base and recommendations for organisation activities in environmentally sound way in the Base (including responsibilities of personnel, use and maintenance of infrastructure objects, to take care the territory of Base, environmental training of military staff, etc.).

Presently the investigations already curried out on the site, indicate that there are some harmfully polluted spots left by Russian Army at the territory of the Adazi Base. According to existing legislation the Base Administration (Commander) is responsible for the base management (including remediation of historical pollution).

Goals of the ongoing activities and those already curried out in the area of polluted sites are:

- to create economic and juridical mechanisms for solution of the historical pollution problem;
- to implement the principle "Polluter pays" for current activities;
- to form economic and juridical mechanisms for pollution prevention and pollution control.

The main approaches used in the Republic of Latvia for solution of the problem of contaminated sites are:

- use of co-financing mechanism for funding of necessary investigation and clean-up activities (state, municipal, international donor and private means),
- making assessment of pollution (common and in some cases also very detailed) of former military sites
- organizing of training for Latvian specialists (including military personnel) ,
- use of assistance from international organizations and from bilateral cooperation with main donor countries as much as possible,
- clean-up pilot projects in main harmful sites,
- negotiations with landowners, investors etc. in every specific case about terms of clean-up activities (clean-up standards, budgeting, land tax reductions etc.).

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Site Contamination Problems in the Republic of Latvia: Ongoing Clean-up Activities and Future Pollution Prevention Plans

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Ministry of Environmental Protection and Regional Development of the Republic of Latvia

Presentation at the Pollution Prevention Symposium in Budapest, 5-7 May, 1999

The main functions of the draft Law on Pollution Control concerning the contaminated areas

- provide inventory and registration of contaminated and potentially contaminated areas in Latvia;
- determine general preconditions for information, investigation and remediation measures in connection with contaminated and potentially contaminated areas;
- determine the financial liability for investigation and remediation measures;
- provide the necessary legal means for State institutions to conduct and administer investigations and remeaditions.

Criteria for investigation of former military sites developed by Latvian and Norwegian specialists

I group – it is evident that site is polluted with hazardous substances and poisons which spread into the environment or the site is contaminated with explosives which all together could cause essential threat to human life and to the environment, detailed investigations and clean-up activities are urgent;

II group – there is only some information about pollution of the site with hazardous substances which could cause threat to human life and to the environment, further site investigations are required;

III group – pollution of site is insignificant and possibility of migration of hazardous substances also is unessential, site investigations are required only in case of change of land use;

IV group – no evidence of pollution and hazardous materials, further site investigations are not required.

Detailed pollution investigations of former military sites carried out in Latvia

- the investigations of Lievarde and Rumbula airfields (with assistance of Germany and Denmark),
- the investigation and remediation pilot project of rocket base in Liepaja district (in cooperation with Canada),
- the investigations of fuel base and site of former tank reparation plant in Riga (in cooperation with Norway),
- ongoing activities in Adazi training field (cooperation with USA and Sweden),
- Liepaja Harbour Environmental Study (Phare Programme with participation of Danish specialists),
- the investigation of a part of the former Dobele tank training range,
- planed activities in a part of former Liepaja Naval Base - Liepaja Karosta district (in cooperation with Canada).

The main goals of the Environmental Security Project

- to strengthen the co-operation and co-ordination between military and civilian organisations;
- to train the military personnel in the environmental management and to prevent further degradation.

Goals for ongoing activities and those already curried out in an area of polluted sites

- creation of economic and juridical mechanisms for solution of the historical pollution problem;
- implementation of the principle "Polluter pays" for current activities;
- formation of economic and juridical mechanisms for pollution prevention and pollution control.

The main approaches used in the Republic of Latvia for solution of the problem of contaminated sites

- to use co-financing approach for funding necessary investigation and clean-up activities (state, municipal, international donor and private means),
- to make assessment of pollution (common and in some cases also very detailed) of former military sites
- to organize training for Latvian specialists (including military personnel) ,
- to get as much as possible assistance from international organizations and from bilateral cooperation with main donor countries,
- to carry out some clean-up pilot projects in main harmful sites,
- to negotiate with landowners, investors etc. in every concrete case about terms of clean-up activities (clean-up standards, budgeting, land tax reductions etc.).

POLLUTION PREVENTION IN THE LAND MAINTENANCE SYSTEM

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Abstract

This paper presents the implementation plan for the Sustainable Development Strategy in maintenance workshops serving the Canadian Land Forces. Workshop surveys were conducted during which opportunities for pollution prevention and impediments to positive changes were identified. Reducing sources of pollution was the primary goal but reducing costs and improving working conditions were also considered.

This initiative will reduce the amount of hazardous materials used and the amount of spent material, which must be disposed of as hazardous waste. Existing equipment is being audited and the requirement for use of high-risk consumables is being reviewed to eliminate or reduce their use. A material substitution program has made progress in lessening the dependence on high-risk products. The paper also discusses progress in developing and integrating the building blocks of an information system designed to track the consumption of hazardous materials and the generation of waste, to identify products containing targeted substances and to evaluate the relative hazards of products required to operate and maintain equipment.

Introduction

During the 1970s and 1980s control technologies were the primary means of combating pollution. This proved valuable for the environment as well as for the economy. It propelled rapid growth of an environmental technologies industry and its associated services. This approach focused on end-of-pipe solutions with little attention given to the origin of the pollution. However in recent years as progress from affordable pollution control technologies leveled off and further advances depended on a more fundamental approach, attention turned to the root causes of pollution.

In North America and elsewhere, environmental policies, guidelines and standards emerged that strongly promoted pollution prevention at source as it was considered to be the most effective means of protecting the environment, eliminating costly waste, and promoting sustainable development. As it became apparent that a purely ecological approach would not be sufficient to sustain the future of mankind, environmental protection was placed in a broader context, which considered economic and social factors. In Canada, a Sustainable Development Strategy that institutionalized pollution prevention across all federal activities was established.

Pollution prevention has been recognized as a major means of achieving sustainable defence activities and a key element of environmental stewardship. A Sustainable Development Strategy commits the Department of National Defence and the Canadian Forces (DND/CF) to limiting the impacts of defence activities on the environment and to contributing to the health and well being of Canadians while maintaining military operations.

Land maintenance system

DND/CF has an active operational presence in all regions of Canada including the Far North. The army, navy and airforce along with the many organizations which provide command and control, communications, maintenance and logistical support have at their disposal 20,000 km^2 of land, over 10,000

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individual facilities and more than 30,000 vehicles. Wherever these activities take place, the potential for affecting human and other natural environments exists.

Intrinsic to having a viable military land force is the maintenance of equipment used to support these forces. Providing this support requires the use of hazardous chemicals and practices, which are not always environmentally favourable. Maintenance activities can result in emissions of acidic and toxic air pollutants, liquid and solid waste pollutants, and greenhouse gases.

Canada's Land Maintenance System consists of first line field units, second line field units, base units and a repair and overhaul facility. The volume of work and age of facilities vary. Vehicle technicians, weapons technicians, fire control technicians and materials technicians at 121 maintenance shops spread across 13 bases provide operation and maintenance services. The workshops provide in-service maintenance to all land vehicles, weapons and equipment of the regular and reserve forces. Support is provided for systems ranging from armoured vehicles and aircraft ground support to small marine motors as well as land weapons, land tactical communication equipment, locks and safes, mechanical devices, electro-mechanical, and electronic equipment. The Canadian Forces vehicle/trailer fleet alone comprises over 20,000 individual vehicles and trailers.

Small workshops having less than 40 personnel are normally associated with first line maintenance units providing preventive and corrective maintenance and recovery activities. An example is a maintenance platoon in an infantry battalion supporting approximately 320 vehicles (fighting and administrative), mortars, crew-served and personal weapons, TOW systems, optical sighting and observing equipment, etc.

Medium workshops employing 40 to 100 persons are typically static workshops in support of small bases or stations. Maintenance support includes preventive and corrective maintenance as well as the replacement of major assemblies. Support to the supply system is also generously provided. Equipment support includes base/station vehicles, weapons, video equipment, etc. The number of each equipment type varies widely from one establishment to the next.

Large workshops having over 100 persons are normally associated with second, third and fourth line units. Large workshops provide corrective maintenance and rebuild or overhaul of assemblies and/or equipment.

Pollution sources

The activities conducted at these facilities consume a large variety of hazardous materials when cleaning and degreasing equipment prior to repair or painting, and for preservation or de-preservation of equipment. Environmentally, the petroleum, oil and lubricant products used in maintenance activities are of greatest concern. These activities generate a large variety of waste products such as oils, engine coolants, hydraulic fluids, chemicals, and waste metals including batteries. Within the workshops, the highest volume source of pollutants resides in the petroleum, oil, and lubricant and related product area. Within this category fuels such as diesel, gasoline, naphtha, and kerosene constitute the largest volume of hazardous products used by the land forces.

The origin of much of the pollution at DND/CF installations is beyond the control of the installation itself. Many of the workshop processes that generate pollution and wastes are the result of the design, operation and maintenance of weapon systems such as armoured vehicles. However, pollution avoidance is most effective when it is pursued early in the design stage. Introducing it as an afterthought at more advanced stages of project development limits the options and reduces the opportunities for success. Attention must be given to the reduction or elimination of pollutants during all phases of the life cycle of weapon systems, their subsystems and support systems.

Pollution Prevention Mechanisms

Reducing the requirement for hazardous materials needed to operate and/or maintain equipment requires careful foresight to implement planned pollution avoidance during the weapon system or equipment design stage. Life cycle analysis during the planning stage can identify opportunities to eliminate or reduce the requirement for hazardous materials that pose environmental risks during the operation or maintenance of the weapon system.

Within the Land element, an environmental assessment is routinely conducted on all new weapon systems and major capital equipment items. A similar process has been initiated for minor capital equipment items to ensure that all acquisitions are considered. An analysis of the hazardous materials required to operate or maintain the equipment or system forms part of the assessment. This process makes environmental impact an integral part of the evaluation of options along with cost, performance, and schedule.

Equipment review

The workshops are required to use prescribed products and processes when carrying out their maintenance functions. It is these prescribed processes and products that produce pollutants either through emissions or spills. Opportunities to prevent or reduce pollution during the in-service stage are being identified.

For existing weapon systems and equipment, a process has been initiated where specifications and standards that stipulate the use of hazardous materials in the operation, maintenance and repair of the system are systematically reviewed. The goal of the review of specifications, standards and technical orders is to reduce the requirement to use toxic chemicals and other hazardous materials or to replace these substances with less hazardous products.

A portfolio is being developed for each equipment and weapon system. The portfolio identifies materials that may pose a hazard to human health, the environment or to the equipment itself and encompasses all materials inherent to the equipment as well as those products that are required in its use and its maintenance. The content of technical orders, technical manuals, technical drawings was augmented through discussions with equipment managers to incorporate any changes which have not been documented. Information on the hazard sources - for example PCBs, radioactive active sources, mineral fibres such as asbestos and coatings, POL products and cleaners and degreasers were identified. To facilitate replacement of undesirable products with less hazardous items, information on substrate composition was gathered.

The portfolio includes an analysis of all the hazards associated with the equipment and recommendations for changes in maintenance products and procedures and in maintenance schedules. The updated maintenance manuals will have a direct impact on pollution avoidance in the workshops. For example, extending maintenance schedules, using extended life products and using dehumidification for preservation of equipment will lower the volume of hazardous products used and disposed of as hazardous waste and will provide cost savings.

Procurement of consumable products used in workshops

As with many other countries, Canada has lists of substances, which are regulated or targeted for elimination. These include ozone depleting substances and substances that are highly toxic, which bioaccumulate and which persist in the environment.

Consumable products used in the maintenance or operation of land equipment are reviewed to ensure that they:

- Generate fewer polluting by-products and/or environmental hazards during use and disposal compared to competing goods and services;
- Contain maximum level reusable, recycled and/or recyclable content to reduce post-consumer waste, without significantly affecting the intended use of the goods or services;
- Are available competitively, for a reasonable price and for delivery within a reasonable time period; and
- Do not contain substances that are targeted for reduction or elimination.

This process adequately controls products that are acquired nationally. One area that is problematic to all workshops is the control of hazardous materials obtained through local (Base and Unit) purchases. Most workshops have storage lockers filled with an assortment of hazardous and relatively non-hazardous products that are neither catalogued nor documented within the section or workshop. Although these products are commercially available, methods and procedures to assess, document or locally control their proliferation have not been consistently implemented across all units and bases. To facilitate implementation the building blocks of a national information system are being integrated and will be made available to all bases and units. One of these building blocks is a module, which provides an assessment of the relative hazards of new products relative to other products in the catalogue and identifies any ingredients, which are regulated or controlled.

Workshop audits

A baseline survey of maintenance practices was conducted at five representative land maintenance workshops. Maintenance facilities on navy, army and airforce bases were visited to look at all lines and levels of maintenance within the land maintenance system. In addition, visits were made to selected private sector maintenance workshops for comparison. The site visits were conducted during the period December 1997 and September 1998. Electrical Mechanical Engineering Workshops visited the included units from all lines and elements:

- A first line field unit,
- A second line field unit,
- A CAS base unit,
- A CMS base unit,
- A repair and overhaul unit
- A general maintenance Support unit,
- A Close support Group, and
- Four commercial maintenance facilities.

The results of the surveys formed the basis for questionnaires, which were sent to the remaining Electrical Mechanical Engineering Workshops. A good awareness of the importance of good environmental practices was found at all workshops with many good practices already implemented.

The level of waste segregation and reclamation was found to be directly related to the mobility of the maintenance organization. First line and Close Support Group units require low cost, simple practices to meet their mobile and tactical requirements. The use of absorbent pads appears to be the most versatile and cost effective means of implementing field pollution prevention measures for highly mobile units. The lack of vehicle carriage space frequently results in the commingling of waste POL streams (e.g., oils an antifreeze) thereby diminishing recycling opportunities and increasing hazardous waste disposal volumes and costs. Other wastes that are typically segregated in static operations (e.g., filters) my also be inadvertently directed to dry waste streams, improperly disposing of the product and increasing landfill waste volumes.

The visited units all possessed a high degree of spill response capability. However, field deployments pose a problem for spill control at petroleum, oil and lubricant (POL) points – whether at a unit's POL point or at tentline. The mix of barrel's, rough terrain and adverse weather conditions, combine to make operations and static pollution prevention means (e.g., spill pallets) difficult or impractical to implement.

Commercial benchmarking
Site visits were conducted at five external maintenance facilities which ranged from small mixed fleets to heavy production facilities. This provided a broad view of how common tasks were conducted within organizations of different sizes and complexity of organizational structure. In general, separate environmental committees were not found and environmental compliance was typically achieved through corporate environmental audits. In large maintenance facilities, formalized corporate programs were well established and responsibilities assigned. The use of a contracted agency to provide chemical management services for all non-production materials was a recent addition to one facility's environmental program. At this facility contractors were required to sign a copy of the firms environmental and safety policy before being allowed to work on-site.

There was little metal segregation at the external facilities. Bulk POL product dispensing and waste product tanks were used at all visited external facilities. Solvent bath servicing and solvent replacement was a contracted service at the visited facilities. This was found to be more convenient rather than an environmental requirement and bath units were not equipped with fume hoods or spill control devices. At the commercial facilities the effect of detergents on the effectiveness of oil-water separators was not a concern and where wastewater treatment plants were in place, they were assumed to be failsafe.

Best Practices

From the site visits and a review of alternative practices proposed by the US military and the US Centre for Hazardous Materials Research, over 40 best practices have been developed for Land Maintenance workshops to consider for implementation. The recommended practices will contribute to the implementation of the sustainable Development Strategy through sustainable maintenance activities.

Best practices have been categorized by workshop size, workshop type and implementation priority. The identification and evaluation of best practices is ongoing and the list will be updated periodically. A matrix of workshop versus best practices has been constructed and will be updated as part of the process to monitor progress toward meeting sustainable development goals.

Impediments

Some of the difficulties found in implementing pollution prevention initiatives could be attributed to:

- Lack of continuity of personnel. Military technicians are posted every two to four years. The person posted in may not be familiar with the equipment or procedures;
- The age of the facility. Where newly constructed or renovated facilities have been constructed around maintenance activities, the greatest gains in pollution prevention have been observed. Conversely old run-down facilities suffer from poor housekeeping and less stringent environmental practices.
- Lack of carriage space frequently results in mixing of POL streams (e.g., oils and anti-freeze) diminishing recycling opportunities and increasing hazardous waste disposal volumes and costs;
- Workshops bear the full cost of implementing new processes/equipment but any cost savings do not return to the workshop;
- Follow-up training is the use of new equipment such as reclamation and recycling units, HVLP paint guns etc.; and
- Lack of information on products.

Information system

Central to pollution avoidance is readily available information. Departmental policy specifies information of hazardous materials will be available to all stakeholders through one information system. Most of the required information already exists but is scattered in a number of electronic systems. Amalgamation of these systems is underway. The completed system will contain cataloguing information on the products (NATO Stock Numbers, part numbers, suppliers, prices), Material Safety Data Sheets, storage and shipping requirements, inventory data, disposal data, lists of alternate products, compatibility data of products with the materials they are used on, product selection tools, and relative hazard risks of products based upon readily available environmental, health and safety criteria.

Summary

Environmental concerns compete with operational tasks for resources. Although Canadian Forces and Land Maintenance System operational tasks have never been more demanding than in the recent past, significant progress has been made by workshops toward meeting Sustainable Development goals. Automotive coolant recycling is present in most workshops and alternatives to hazardous or polluting materials and processes are being sought at all organizational levels.

To conform to best environmental practices our maintenance workshops are working toward:

- Reducing hazardous solids and liquid waste generated by daily maintenance activities by reducing the amount of product used to the minimum required for maintenance activities and reusing and recycling products;
- Replacing or modifying processes which result in an environmental burden;
- Replacing hazardous materials with the least harmful product which will get the job done; and
- Optimizing maintenance routines and schedules to reduce fuel consumption and probability of emissions and leaks.

Strategy of Military Lands Reusing in Lithuania

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The Soviet army left Lithuania in 1993. Upon withdrawal they have left about 500 various military installations. There were 277 Soviet military bases in which 462 military units were located at that time. Sizes of military sites varied in a rather wide scale – from less then 100 m^2 (workshops) to nearly 14000 ha (forestry). Military sites according to their sizes are presented in Table 1. All military sites occupied territories of 67762 ha, which makes 1.04 % of Lithuania's territory. Currently, 16.7 % of the territory has been left to satisfy the Lithuanian military needs and the rest has been transferred to civil users.

Table 1. The distribution of military sites according to their sizes

Area (ha)	Number of bases	Total area (ha)
Less than 1	60	17
1-10	78	309
10-100	80	2718
100-1000	45	13594
1000-10000	13	37262
Over 100000	1	13862
Total	**277**	**67762**

Military sites situated on the territory of the Republic of Lithuanian had served specific purposes - from the establishment of military settlements and military forestry areas to the shooting grounds and military airfields (Table 2). That had significantly impacted upon the scale and character of the environmental pollution and destruction in the occupied territories.

Table 2. The distribution of military sites according to their destination

Type of military site	Number
Motor-rifles units	3
Landing-party units	10
Artillery units	4
Engineering, transport, railway, supply and building units	33
Airfields, aviation units	15
Storage of oil products and rockets fuel	4
Rockets and antiaircraft bases	31
Warehouses	21
Communication units	35
Grounds and shooting-ranges	12
Border troop units	20
The military infrastructure (settlements, schools, hospitals, shops, military forestry, military tribunals)	63
Training and teaching centres	6
Repairing enterprises	4
Tank units	1

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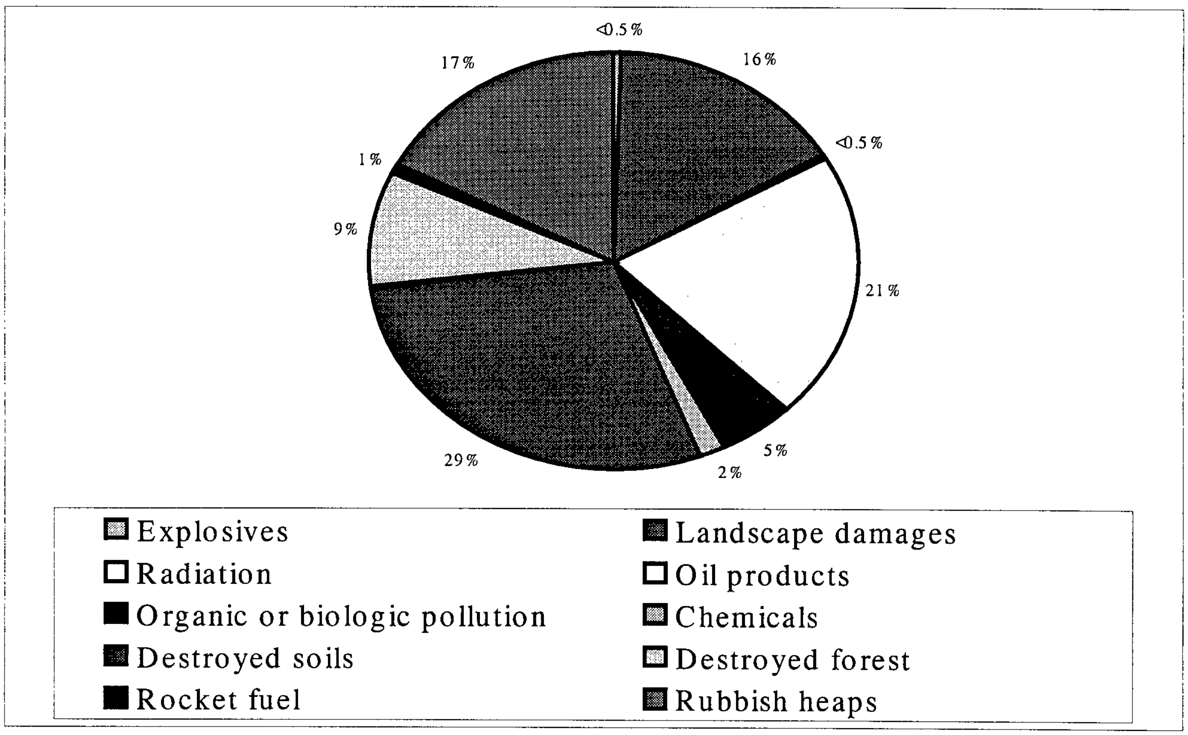
Unites of other types	15
Total:	**277**

When Lithuania overtook the Soviet military bases, an Evaluation Committee comprising local specialists has been established to evaluate environmental situation in the former Soviet military bases. One of the main tasks was to identify effective measures, which applied, could prevent further spreading of pollutants. Lithuanian experts recorded 2743 sources of the actual pollution in the former military lands (Tables 3, 4). We can see in Table 5 that only in 14% of all military bases did not contain pollution sources. However, the remainders of 200 types of poisonous chemical substances have been found in the rest 86% of the former Soviet military sites. Many different flammable materials have been also left in those territories. Ruins of the former buildings and other sources of potential danger are present almost in every military site.

Table 3: sources of the actual pollution in former military lands



As we can see from the above-mentioned numbers, pollution caused by oil products and rubbish-heaps prevailed in the military sites as well as the landscape and soil damages. 478 rubbish-heaps were found in the military sites, which makes 17 % of all environmental damages. There are about 333000 m^3 of waste in 1188 ha of the polluted territory. The main waste originates from buildings and metal scrap which amounts to 96000 m^3, military activity waste makes 88000 m^3, mixed household waste roughly equals to 84000 m^3 (Tables 6, 7). Streams of waste water and wind transport heavy metals particles, oiled dust, bitumen and other break-up products from rubbish-heaps into the clean sites. Natural ecosystems have been severely affected by the log-term military activity in the restricted military sites and they cannot be easily restored, sometimes causing harm to the health of inhabitants of those territories. The main problem of reusing military sites therefore at this time is the prevention of pollution being spread further, and

specifically, immediate localisation and liquidation of those pollution sources which raise direct danger for human health and environment.

Table 4: Types of territories damages and their distribution

Type of fixed damages	Quantity*	Area (ha)
Explosives	12	DC**
Landscape damages	438	7140
Radiation	9	DC
Oil products	566	399
Organic or biologic pollution	137	14
Chemicals	56	DC
Destroyed soils	778	11137
Destroyed forest	249	3293
Rocket fuel	20	DC
Rubbish heaps	478	1288
Total	**2743**	**23271**

* - Number of pollution sources.

** - Dotted concentration.

Table 5: Distribution of pollution sources

Quantity of pollution sources in military site	Quantity of territories	Total number of pollution sources
No one	41 (14%)	0 (0%)
1-5	94 (35%)	268 (10%)
6-10	59 (21%)	447 (16%)
11-20	50 (18%)	750 (27%)
21-50	27 (10%)	840 (31%)
More than 50	6 (2%)	438 (16%)
Total	**277 (100%)**	**2743 (100%)**

* - Number of rubbish-heaps.

Having estimated the results of research of environmental situation in the military sites, the latter territories have grouped according to their level of investigation and the necessity of preventative measures, clean-up and restoration works. In addition, every territory has been grated a certain category according to the listed criteria. The categories are described by indexes A, B, C, D, E, F (from the highest damages to the least). Every military site has received an index consisting of two letters (for example, BC). Here the first letter describes the level of investigation and the necessity of researches or preventative and cleaning works, the second letter means the level of the landscape destruction and the necessity of restoration works. Only one former military territory is ascribed to A category, namely Šiauliai airfield, however territories, which, according to pollution level, are ascribed to B, C and D categories, make about 80% of all former military sites. Similar situation remains in the field of landscape destruction.

Table 6: The main types of wastes in military landscapes

Types of wastes	Quantity*	Thousands m^3

Building/metal scraps	157	96
Ruins	50	25
Waste of military/economic activity	182	88
Mixed industrial waste	17	35
Mixed household waste	65	84
Other	7	5
Total	**478**	**333**

* - Number of pollution sources.

Table 7: Types of rubbish-heaps and total area

Types of waste	Quantity*	Area of accumulation (ha)
Polluted area by waste or litter	272	1120
Rubbish-heaps and ruins	168	56
Waste-heaps	38	12
Total	**478**	**1188**

Despite of their future utilisation the following preventative measures are being applied:

a) removal of radioactive pollution sources,
b) removal of explosives,
c) isolation and removal of oil pollutants,
d) removal of aggressive waste and scrap,
e) neutralisation and removal of chemicals.

Landscape renovation may be divided into three main stages:

1) preventative,
2) curative,
3) reconstruction.

Preventive works are considered to estimate the danger raising from military sites and pollution migrations and to stop dispersion of explosives or dangerous materials. These measures are to predetermine the nature of protection systems and regimes to be established in those territories.

Curative actions include almost all means of prevention and cleaning of the territory from pollutants and other dangerous and explosive materials. Also, territory restoration in most cases foresees arrangement of buildings, full or part re-creation of the entire relief, green plantations and restoration of the soil layer. Reconstruction of territory is its analysis with regard to pre-military use and works directed to complete restoration of the former environmental situation.

Restoration of a military site is a complex renewal of degraded grounds, rebuilding of economical, ecological, esthetical and other values. Engineering and biological stages of reconstruction works are included. The engineering stage is the primary preparation of the site for future uses (drawing disturbed surface, forming slopes, transporting and spreading new active ground to areas under reconstruction, building roads and hydrotechnical installations, etc). The biological stage includes the agro-technical phytoland replanting and restoration of productivity of renovated surface by engineering means.

First preventative works, which have been done in all military sites, were the removal of all sources of radioactivity and explosives from the areas. All radioactive pollutants found on the territories have been moved to the special dumping site. Radioactive pollution is therefore hardly probable at present. A few separate sources of radioactive emanation might be still detected in territories where devices or their parts contaminating radiation had been stored.

According to the prepared classification, military sites and individual objects in which preventative and clean-up works have to be carried out first have been selected. Works initially shall start in the Šiauliai airfield. A renovation project has been prepared and works have started. Its is the most polluted and damaged military site in Lithuania. Presently, the Danish company Krüger Int. Consult A/S in co-operation with the "Baltic Consulting Group" Ltd carries out cleaning works by extracting free oil products' accumulations from ground water surface using hydrodynamics method with oil skimming on the territory of the former fuel base at the airport.

Preventative work programmes based on the principle that pollution sources must be removed first in order to stop further pollution of grounds are being developed. The ground polluted with oil products is considered as a secondary source of pollution. According to the existing requirements of directive LAND 9-95, industrial activity in territories polluted with oil products is permissible only when the concentration of oil products in the ground is less than 2000 mg/kg. This concentration in the Siauliai former military airport ground varies from 2000 mg/kg tol 5000 mg/kg.

Similar project is being prepared for the former rocket base in Taurage. Currently, preventative cleaning is on-going and technical project design is being prepared. In total, 10 military sites have been investigated in detail to date, based on which results, new projects related to ecological optimisation and renovations for other territories will be prepared. They suggest what pollution preventative works must be carried out immediately in other territories. Such territories have been selected in different Lithuanian areas so that they reflect types of pollution and typical landscape damages that could be seen. Newly developed projects will include renovation of those territories, and other former military sites will be managed in the future.

In all territories where groundwater cleaning works are being carried out, there is a requirement that water after cleaning must comply the drinking water standard requirements. This principal requirement applied in the process of removing all types of pollutants determines the selection of cleaning measures and technologies.

Monitoring as one of main preventative measures is obligatory for both surrounding of cleaning sites and sources isolated and protected from spreading pollution. In some cases monitoring helps observe the cleaning process and evaluate the level of cleaning, but it is not obligatory after the end of cleaning works. In other cases, monitoring lasts 10-20 years and foresees observations of the process of spontaneous self-reclining and an assessment of danger of pollution spreads and timely blockage of their ways. In the Šiauliai airfield, Vilnius "Northern borough" and some other former military sites such monitoring is on-going.

At present, some former military sites are being used by civil society to some extent. The airports in Šiauliai (Zokniai) and Karmelava (Kaunas) are being reorganised in free economical zones. The new functions are being taken to develop business in Kedainiai airport.

The majority of military sites, which are located in urban zones, are assigned for living or industrial sector. Ecological optimisation of the territory requires an agreement on its functions. They must be functionally related with contiguous territories. In such territories the following sequence of works as preventative measure against future pollution spread is being designed: all sources of pollution should be removed from surface and priority zones of greenery formed. They could make barriers for streams of pollutants and individual businesses – industrial zones from living territories and in this way to improve environment at living zones.

It is expected to create a modern business centre in Vilnius "Northern borough". This big military site is located in the centre of Vilnius City and has very important value for future Vilnius development. Radioactive and oil pollution sources have been removed from there. Groundwater monitoring is being carried out in this military site. Various enterprises and government institutions have settled in the former military barracks. In future, it is foreseen to

pull down those barracks and to rebuild the whole territory in modern style. It is expected to realise the project in 10-15 years.

Having removed pollutants, a centre for illegal immigrants has been opened in Pabrade former military site. "Rukla" military borough, which is between the Jonava and Kaunas cities, was adapted for living ward. Aggressive sources of pollution have been removed, new communication lines have been laid and now few thousand inhabitants live there and continue working in Kaunas, Jonava or surrounding regions.

University of Klaipeda has been settled in the former military barracks of the Klaipeda city. In Nemencine centre of radio-reconnaissance the environmental education centre has appeared. Various enterprises have settled in some smaller military bases. It does not however mean that environmental situation in those military sites is friendly. Only first steps towards their renovation have been made and it needs to be built upon by carrying out full ecological investigation in the nearest future. Besides that, there is an outstanding problem that the majority of military objects in which valuables were stored or equipment that would have been suitable for business were destroyed and building ruined.

Clean-up and re-utilisation of former military sites is identified as persisting problem. Ministry of Defence has overtaken about one third of former military territories, but it is not in a position to take care of all its territories properly. Better situation is observed in former military forestry. The Ministry of Defence together with the Ministry of Environment and environmentalists from other institutions have listed twenty priority military sites, which need to be renovated as possibility arises. A Special Group has been created comprising environmental, economical, law and other specialists representing concerned institutions. The Group is charged with the task to prepare proposals concerning future renovation of former military sites.

A Joint Committee is currently being created by the Ministry of Environment and the Ministry of Defence. Its function will be to organise preventative activity in military sites, which now are used by Lithuanian soldiers. The Committee shall prepare methodology for resolving environmental protection problems working military sites in order to prevent the creation of new pollution sources. Scientists from Vilnius Gediminas Technical University, Geographical, Geological, Ecological, Physics and other institutes usually carry out field and laboratory researches to estimate and control environmental situation in military sites. The direct result of scientific researches is the preparation of optimal scenarios for renovation and reusing of the former military sites.

Future necessity of military sites renovation is determined by three general aspects:

1) scale of pollution and environment destruction,

2) danger caused to human health and environment,

3) the perspective of their future usage.

For future restoration all territories are divided into several groups:

1) territories which do not cause danger for human beings or environment and in future, will be used for military purpose;

2) territories which do not cause danger for human beings or environment at present but in future using the sites for military purposes, the some problems can arise again;

3) territories, which cause danger for human beings or environment and in future they are planed to be used for military purposes;

4) territories which do not cause danger for human beings or environment and in future will be used for civil purposes;

5) territories which do not cause danger for human beings or environment at present but in future even not using the sites for military purposes the problems can persist;

6) territories which are causing danger for human beings or environment and in future are planned to be used for civil purposes;

A landscape renovation plan must be developed for every military territory or its part according to the above-listed site utilisation aspects.

Renovation of military landscape includes:

a) arranging for restoration of damaged surface, making forms near to natural landscape;
b) cleaning polluted sites and removing pollutants and waste;
c) re-naturalisation.

Preparing a renovation project for military site, legal documents for future usage of the site are required and zoning of the whole territory for future usage must be done. Renovation can also be done in those damaged territories, which are foreseen for military purposes.

Depending on territory future utilisation new renovation projects describe:

a) renovation level,
b) renaturalisation degree.

Territory's location and its future usage determine the level of renovation. The following measures of renovation are planned independently of the future usage:

a) removal of explosives,
b) removal of waste and scrap,
c) neutralisation and removal of chemicals,
d) removal of s of radioactive pollution source,
e) removal of erosion sources.

Territories allocated for replanting forests need additional measures:

a) searches of explosives and their removal from the depth not less than 1.5 m,
b) surface drawing in medium and strongly damaged grounds and quarries.

Necessary additional measures for the territories foreseen for agricultural development:

a) drawing of all damaged ground,
b) active ground level forming,
c) investigating and projecting land-reclamation of the territories.

Two levels of territory cleaning from pollutants are indicated (Table 8):

The first level is applicable to sites, which are used for settling down, intensive recreation, also for water protective zones, sanitary zones of water places, for all carst territories.

The second level is applicable for sites used for other (economic and military) purposes.

Renovation projects foresee the clean-up of polluted ground and formation of natural cleaning conditions.

Table 8. Maximal permissible levels of cleaning pollutants in territories mg/kg

Pollutants	I category	II category
Oil products*	300	1000
Pb	100	600
Cd	2	20
Cr	150	800
Cr(VI)	25	100
Co	100	300
Cu	200	600
Ni	200	300
Hg	0,5	10
Zn	500	3000

* For inhabitants, water protection and sanitary zones – 20 mg/kg.

The renovation of the landscape's stability is a complex of reconstruction measures forming natural varieties, which must create the conditions for spontaneous natural renovation of natural complexes in the cultivated parts of the territories.

In territories where renovation is foreseen, natural level of water is restored by technical means, new conditions are created for natural communities of plants and formations of animal populations and restoration of greener cover.

Natural complexes or their fragments formed during renovation have larger natural variety than antropogenic complexes; they are more resistant for negative antropogenic activity and more effective for retaining of landscape's stability.

Scenarios of ecological optimization are created according to the restoration and optimization of typical military sites. According to the plan of optimization and renovation, first problems are indicated of cartographic localization of main works and establishment of renovation costs.

In military sites, existing in uninhabited districts, first it must be attempted to renovate the territories according to its usage and saving ecological stability of the object.

In all cases when projects of renovation of military landscape are prepared, the cleaning polluted ground or conditions for natural re-cleaning are foreseen. In those cases when there are not any spreading sources of pollutants, the main measures for tiding soiled territories are to remove waste and ruins from military and adjacent sites. Aggressive waste must be transported into specially arranged and steadily observed landfills. Those ruins of buildings and equipment, which can be rebuilt or used in future should not be destroyed.

In the meanwhile, the works on sanation of the territories are almost not done (only for a couple of the largest military bases the sanation projects are being prepared by foreign expenses). At present it is not absolutely clear, who must take care of arrangement of the soiled and damaged territories. The Government, by its decision, obligated the landowners or their tenants to make those works, therefore they are not interested to invest great sums of money for cleaning the Soviet "heritage", because they are not the owners and they have not enough capital for this.

The renovation of military sites in Lithuania demands effective, expensive and urgent sanation-restoration measures. Lithuanian researches steadily take care of environmental situation in military sites. Scientists from main scientific institutes carry out common works in this direction. We hope that co-operation between different Lithuanian institutes of scientific researchers together with business enterprises and Government institutions and partnership intercourse with foreign specialists will help us more faster and more effectively to solve renovation problems.

SOCIO-POLITICAL TOOLS IN THE IMPLEMENTATION OF ENVIRONMENTAL POLLUTION PREVENTION AT MILITARY BASES

by

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INTRODUCTION

Our technical society is often forgetting about a human role. However, the human role is still very important to function of a technical and technological systems. Not only the technologies but also socio-political tools are also necessary to the implementation of environmental pollution prevention at military bases.

PRINCIPAL SOCIO-POLITICAL TOOLS

There are the following principal socio-political tools in the implementation of environmental pollution prevention at military bases:

- environmental policy
- internal military legislation
- personnel, economic and financial conditions
- control
- science and research
- education
- emotional connection with environment

Especially increasing the role of environmental education results in increasing of efficiency the environmental pollution prevention.

EDUCATION

Education to environmental responsibility as a constituent part of a complex, purposeful and permanent formation of a personality is of outstanding importance today. But there are some problems in educational instruction necessitated by a narrow scope of outlook i.e. that outlook which lacks political and economic aspects, having potential serious consequences for students/listeners.

Organic integration of two systems below is supposed to be an effective prevention against this:

1. socio-politico-economic education and instruction, and
2. special natural science and environmental responsibility.

The first system includes accomplishments of fundamentals of social studies, philosophy, and formation of political attitudes, while the second one includes a wide knowledge of particular components of nature, their mutual relations and connections, including those to mankind and his activities.

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Quality of co-operation and integration of both systems with regard to individual constituent parts of the educational process is not always the same. But both are absolutely indispensable, helping to fix the principal idea of inseparability of mutual politico-economic-ecological relations, with accent on a class basis of the relationship, man-nature, that is, ecological responsibility. This must be permanently intensified to implant in students/listeners mind the condition sine qua non - that is, necessity of economic development hand in hand with protection and improvement of environment of nature and life, necessity of sustainable development.

Environmental responsibility in education is conceived as a part of complex training.

Given that educational and instructional processes cannot be separated an attention will be given in the following to contents and methods of environmental protections, considering complex education and applications in practice.

SOME SPECIAL TEACHING PROBLEMS

There are students studying combination of economy and environmental protection on Military University in Vyçkov. Coming students often have narrow views about environment protection. Their opinions are assumed to result from:

1. Previous restricted ecological and environmental education in instruction and social practice, monothematic discussions, not taking into account very often political and technico-economics aspects.

2. Defensive positions in retechnicoeconomic approaches, which do not consider or proclaim ecological aspects of the development of state economy and society.

3. Lack of objective environmental estimation of some regions in Czech Republic.

In fact, graduates are very well trained in ecology and environmental protection. But they are not in everyday practice. The same applies to their participation in ecological courses and public activities. They are also not well prepared for possible disillusions and encounters with misunderstanding. Thus, educational activity in applied disciplines must be completed by practical views on environment and development. A deeper approach to given problems is wanted here to eliminate any passive or even apathetic behaviour or disillusion when facing problems in practice. A firm and decisive behaviour of graduates who finished their studies on environmental protection is an indispensable condition not only for their own profession but even for public and pedagogical activities. They must be honest and precise with any information they provide society, either from their research or in their public or professional teaching.

Themes of theses are very important, too. To illustrate this, theses closely devoted to research of activities affecting an environment which do not emphasise range of dependencies, interactions between social activities and environment, and which do not consider causes of defects and do not take steps to remove them, cannot in any case help to shape a professional profile of a graduate. Without a complex approach and understanding of wider circumstances, thesis become useful only for understanding and methods, for a partial result or for education to self-activity. But such a way of thinking can never establish a realistic approach to problems considered from a socio-political or economico-ecological viewpoint. On the contrary, a negative behaviour may occur here to an initiator of such activities or even to society if a student is well aware of negative effects of socio-economic activities on a particular environmental component or biological detail.

Thus, besides themes incorporated in the curriculum and syllabus, it is necessary to intensify the process of complex education to environmental responsibility, emphasising politico-economic aspects by means of new, spontaneous and scientific form. Contents and methods used in teaching are supposed to contribute to this objective.

SOLUTION TO PROBLEMS IN QUESTIONS LECTURES

Students are acquainted here with contents of instruction in accordance with the syllabus and curriculum, as well as with wider aspects between ecosystems and technico-economic or socio-political systems. For this purpose a scheme of relations among individual landscape subsystems was set up, as well as a scheme of means for protection and creation of an environment in a broad and strict meaning. In the first case it is a model which emphasises inseparability of natural ecological, technico-economic and socio-political affinity. In the second case there are means covering the field of political, theoretical and practical operations (means in a broad meaning) which are superior to proper ecotechnical devices for protection and creation of an environment (means in a strict sense). These are realised in political spheres, further by methods of prognosis, conception and legislation, including state economic policy. Theory and conception of protection in non productive sphere is established through gnoseological, analytico-synthetic, prognostico-conceptual and didactico-educational methods. Material basis of protection in economic sphere rests on productive-economic and materio-technical methods. The above three spheres result in a sphere of realisation (see above).

In principle, these schemes are confronted in each lecture. In addition historical developmental trends of environmental systems are emphasised here as a result of co-operation of all spheres mentioned above. Their present state is analysed in courses, being a good basis for making proposals for individual environmental wholes. Thus, an extra lecture is devoted to a theoretical statement of common criteria to project development of socio-economic activities on a given locality.

TRAINING

Beside standard activities, we aim to equip students with abilities of how to solve realistically practical problems of environmental practice. Students are taught to read maps and projecting documentation; moreover, they tray to construct general schemes of relations for individual model ecosystems and to project depends on range and contents of instruction; including schemes of relations and diagrams of progress as well as own global proposals of individual activities and general developmental conception of landscape wholes. For this form, training in terrain and excursions to military training areas and basis are used to teach students to recognise a terrain and to collect data both in the field and from the literature. All activities presented here including seminars (see later) are carried out with the aim to establish a variant project for sustainable development of a given locality. Students are instructed not to behave conventionally but to solve problems with respect to their theoretical knowledge and skills from all disciplines. Problems in training are very often formulated so as to correspond to some extend to themes of theses.

SEMINARS

To qualify mutual relations of ecology and economy, of environment and military activities, we modelled four situations, simulating various social approaches.

The First Situation.

The first situation (exploating situation) is preferring momentary economic (military) affects, not taking into account an eventual damage of sources and environment, which usually occurs after a time. Students are informed about harmfulness of partial environmental concessions (e.g. governmental exception to law of air or water protection) which are very dangerous to landscape and environment. The same applies to small for-environmental actions with lower effects compared to previous against environmental decisions. This is the most difficult situation for students and teachers because a problem must be solved here, interfering with political, economic, technical and social sphere. This is the problem of some standing in social practice, resulting from a lack of discipline, banal or short sighted prognoses, which do not estimate an environment from wider aspects, i.e. as a dialectical unity of geoecological, technico-economic and socio-

political subsystem. These faults may result from irresponsible, misuse of natural resources and environment, either through ignorance or because of the pursuit of personal rather than societal goals. The faults may be conscious, resulting from personal or collective interests which are held above interests of whole society, or unconscious, resulting from ignorance of general environmental affinity because they will solve in practice professional problems as well as those concerning propaganda, education and conviction of not only workers of production but also workers and personnel of state management.

The Second Situation

The second situation issues from the idea that environmental actions represent only investment absent of economic profits and that economy cannot be introduced in environment. This is a consequence of stereotyped opinions about economic effectivity of investment, that means, that contribution of a better environment can be described verbally, but cannot be expressed financially. However, environmental investment is considered as necessary, being in the first place verbally but very often in the last one practically. Student's task in simulated situations is to discover opinions of an investor, designer or supplier, to convince representatives of state bodies about truth, and to press upon them to change or complement projected documentation, technology, etc. The situation may be arranged as several variants, using various (real or simulated) character qualities and a different knowledge of students about particular human activities. But a final solution must not ever be harmful to universal and dynamic social development. It must include a method of objective economic estimation of environmental investment, or its outlining at least.

The Third Situation

The third situation (conservating situation) issues from correct principles, and requires creating and protecting ecologically balanced environment/landscape and its components as a factor of harmonic advancements of economy, infrastructure, human modes of life and health. Unfortunately, the principles are not applied in concrete in concrete technico-economic and socio-political conditions. Thus, in the simulated situations students of such inclinations are persuaded morally with the help of others of the conservating situation, convenient only for National Parks, National or State Reservations, etc. The arranged situations explain the necessity of realistic applications of science and research in practice and harmful approaches leading finally to extensive utilisation of partial productive potentials of an environment/landscape.

The Fourth Situation

The fourth situation is based on the principle that environmental investment is economically effective, i.e. economy/military training activities is in harmony. Students are taught, at least theoretically, to quantify phenomena considered mostly as qualitative (health and psychic state, aesthetics, etc). In the imitated situations, opposite to this principle, they work out arguments for economic effectivity of environmental protection, with reference to theory and methodology.

The simulated situations are aimed to equip students in all four cases with needed habits and abilities to react in practice to various situations and the claim and promote adequate devices and guidelines, proposals and ideas standing on right theoretical principles and practical knowledge. Universal advancement of society must be respected here. As there are groups of 5 - 10 students, findings from social psychology about interpersonal relations in small groups may be used here. In case of hesitation or unwillingness to co-operate, a dialogue or brainstorming is used, as well as situation and imitation methods, approaching closely to practice. Tape recorder or video is recommended here for analysis and critique.

CONCLUSION

All above cited methods are aimed to prepare military specialist with a wide socio-political understanding in addition to the studies speciality, i.e. those specialist whose attitudes and activities will help to spread environmental findings among army members as well as broad public, improving and protecting an environment.

CONVERSION OF HIGH EXPLOSIVES

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An affordable and short-term solution to destroy the high explosives of unexploded ordnance is burning them.

Military high explosives are realized to provide a propellant (propulsion) or a destructive effect (detonation) in munition. The commonly used high explosives can be seen in the summary of fig. 1. High explosives, rocket propellants or propellant powders hardly ever contain pure high explosives. Normally there are mixtures which have to be split up into their individual components when preparing them for conversion. This is relatively simple in the case of high explosive charges (fig. 2) and still feasible for single base propellants but very difficult for double base propellants as they are available in form of solid propellant mixtures. Dissolving and separation of such propellants are very expensive and take much time.

The idea of diposing of or converting high explosives into harmless products first occured in 1989, after Germany's reunification, when the annuated high explosives stored in the former GDR turned out to be available in enormous quantities. About 300,000 tons of ammunition had to be disposed of. The ammunition did not fulfill Western safety standards and, according to international standards, had been stored for too long (fig. 3).

The disposal procedure which the German Armed Forces used to apply was disassembly of the munitions, which means that they separated the high explosives from the metal parts and then crushed them to burn them in the open air. This combustion is uncontrolled and entails considerable immission of harmful matter in the air, most of all nitrogen monoxide.

Demilitarisation means in this case classification of the ammunition, removal of detonators and H.E. charge.

For the removed H.E. charges, there are different possibilities, e.g. recycling, chemical conversion into valuable products, see fig. 4.

In the chemical point of view, most of the explosives are highly nitrated aromatic compounds, highly nitrated heterocycles or nitric acid esters. Due to the multitude in reactive families, the old high explosives were clearly regarded valuable raw material for chemical synthesis.

Technical reactions are in most cases reduction, oxidation or hydrolysis of a molecule. In the case of nitroaromates, only the reduction process renders valuable matter, see fig. 5.

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CHEMICAL CONVERSION

The most important one of the nitrated aromates is 2,4,6 trinitrotoluene, generally known as TNT. TNT, for its reactive nitric families, is especially suited for a chemical conversion. To eliminate the explosive characteristics from this compound, the NO_2-families have to be removed or converted. This is best achieved with catalytic reduction which employs hydrogen, H_2. The resulting 2,4,6 triaminotoluene (TAT) has no explosive character. Reaction is achieved with 98% efficiency and was first carried out by Hein and Wagner in form of a lab-scale test [1]. In the 70ies, BASF tried to manufacture isocyanates to serve as educts (basic material) of polyurethane [2, 3]. From 1990 on, the armament industry (Rheinmetall and Dasa) installed pilot plants to hydrogenate TNT [4, 5].

Hydrogenation of TNT leads to 2,4,6 triaminotoluene in a first step. Using $NaBH_4$ and applying tough conditions like high temperature and pressure, it is possible to hydrogenate the aromatic ring to methyl 2,4,6 triaminocyclohexane (fig. 6, 7).

Hydrogenation of TNT is achieved in polar solutions with intensive stirring and adding a catalyst under simultaneous introduction of hydrogen. Reaction can be observed with ^1H-NMR and IR spectroscopy or with thin layer chromatography. Hydrogenation is achieved in several steps (fig. 4), reaction velocity being a function of temperature and catalyst to a large extent. Low temperatures are sufficient to obtain reaction. The hydrogen consumption at 25 to 35°C is very high, at 60°C the reaction velocity and the desorption of hydrogen are competing (fig. 8). We tried four types of catalysts and found out, that the best was palladium (fig. 9).

With 2% palladium catalyst relative to the TNT mass, reaction can no longer be controlled. The strongly exothermic reaction ($\Delta H = -1850 kJ \cdot mol^{-1}$ TNT = $-8145 kJ \cdot kg^{-1}$ TNT) requires small reactor volumina and large heat exchange surfaces for cooling (fig. 10) [6,7].

The influence of the solvent is shown in fig. 11. The consumption of hydrogen is used as a measurement unit for the reaction velocity. Over a wide range, the reaction velocity is proportional to the amount of catalyst (fig. 12). To control the reaction, defined temperatures and low percentages of catalyst are advisable (fig. 13).

A continuous installation for the hydrogenation of TNT is shown here. There, TNT is dissolved in relatively small amounts. In a solution of 5 - 10% there is no danger of detonation or deflagration. Such solutions are not detonable (fig. 14).

Hydrogenation of the benzole core of 2,4,6 Triaminotoluene or TNT is achieved with the conversion of $NaBH_4$ (fig. 15) [8,9]. This creates Methyltriaminocyclohexane (MeTACH) which can be available in 8 potential stereoisomeres (fig. 15 shows only one stereoisomere).

The use of $NaBH_4$ to achieve core hydrogenation, however, proves to be very expensive. Trials to transfer TNT with hydrogen in the presence of catalysts directly into methyltriaminocyclohexane supplied only unsatisfactory yield [8].

TAT is very reactive and not stable at higher humidity (fig. 16). Interesting possibilities of synthesis which would be at hand are the conversion of 2,4,6 Triaminotoluene with phosgen ($COCl_2$) into 2,4,6 Toluenetriisocyanate (TICT) [10] or hydrolysis into 2,4,6 Trihydroxytoluene (THT) (fig. 17).

Tri-isocyanates can be used to serve as an additive for di-isocyanates like hexamethylene di-isocyanate used in polyurethane formulations by the industry, with which the properties of plastics could be influenced, as tri-isocyanates lead to tridimensional polymerisation (fig. 18).

As core-hydrogenated iso-cyanates are considerably less sensitive against UV radition than aromatic isocyanates (the secondary chain is stabilised against attack by radicals), a simple catalytic hydrogenation of TNT into methyltriaminocyclohexane is desirable [11].

Presentation of 1,3,5 trihydroxybenzole (phloroglucinol) obtained from 2,4,6 trintirobenzole (TNB) is achieved in the same way as the synthesis of 2,4,6 tri-hydroxytolouene (fig. 19).

Another example for the chemical conversion of high explosives is hydrolysis of glycerine-trinitrate. Hydrolysis however, produces useful matter only with nitrates. Nitramines like hexogen are decomposed into formaldehyd and ammonia with this type of conversion [12], fig. 20, 21.

Commercial Aspects of Chemical Conversion

The products obtained from the chemical conversion of high explosives are all classical chemical basic materials which are already produced in large quantities. The market possibilities are correspondingly unfavourable. This applies most of all for 2,4,6 toluene tri-isocyanate, cellulose, glycerine, pentaerythrite and ammonium nitrate.

Phloroglucinol (see above paragraph) serves as a synthesis element in the pharma industry and moreover as an additive for cosmetics and photo developers. The price for phloroglucine is about 180 to 220 DM per kg. A new way of synthesis would be interesting for this valuable product. As, however, the worldwide need in phloroglucine is about 150 to 200 annual tons, provision of 15 to 20 million DM investment funds required for the establishment of a plant to manufacture phloroglucine from tri-nitrobenzole is uninteresting [13] (fig. 22).

The development of a chemical process using high explosives as raw materials needs time and experience in high explosives and their chemical processing. The estimated time schedule is given here (fig. 23).

Biological Decomposition of High Explosives

Decomposition of high explosives using bacteria would be imaginable. However, the problem is the low solubility of the high explosives in water which represents the medium which the bacteria need. To be able to dissolve TNT, the solubility in water of which is about 0,5 mmol. $\cdot$ l $^{-1}$, in a measurable time, feeding of 20mmol glucose and ammoniumsulfate each is necessary. TNT up to 50mmol $\cdot$l $^{-1}$ is soluble in alcohol water solutions (fig. 24).

The low solubility, temperature stabilisation of the solution to 35 - 40°C and adding of glucose, ethanole and other nitrogenous or carbonic nutriments needed by the bacteria cause enormous expenditure of funds so that a large-scale plant for the biological decomposition of high explosives appears impossible. The biological conversion of TNT works only if the process is split up into two different processes, an anaerobic and an aerobic process with two different types of bacteria and process parameters (fig. 25).
This is still completed by the fact that about one third of the formulation is reduced only partially [14]. The metabolites which still contain nitrogen families are by far more poisonous than TNT. Other explosives like HMX and RDX are hardly processible because they are nearly unsoluble in water [14].

Another disadvantage is the fact that high explosives are available as mixtures (compounds) in most cases so that intensive processing and chemical pre-treatment is necessary, to have the substances ready for biological decomposition [15].
A normal double base propellant contains lead and copper salts which are highly toxic to all bacteria. A separation of these materials is feasible but not payable (fig. 26).
The problems of the bological treatment of H.E. are the low solubility in water, the high energy and nutrition consumption, the sensitivity of the bacteria to metal salts and the incomplete degradation of the high explosives with the formation of very toxic metabolites (fig. 27).

High Explosive Recycling

Military high explosives are normally crystalline organic compounds, which can be recrystallised. Recycling, i.e. cleaning and recovery of high explosives like TNT, HMX, RDX in principle, is possible, but the value of these substances has to be considered. One kilogram TNT for civil or military purposes is available on the world's markets for 1 to 5 DM, according to quality, RDX for about 25 to 30 DM and HMX for about 60 to 80 DM. Thus, recycling appears interesting only for HMX, as large quantities of solvents and suitable facilities are required for the pocessing of high explosives that have to be subjected to the relevant approval and authorisation procedures. Recovered high explosives have to be re-qualified for military or commercial use, which means that they have to pass a comprehensive acceptance test procedure (fig. 28).

Use in Civil High Explosives

It was often suggested to crush military H.E. charges and to add the residues to civil high explosives. The problem which occured there was manifested by the different character of regulations and requirements that apply for military and civil high explosive charges and their various qualification methods.

TNT for example presents a very negative oxygen balance (-74%) which permits adding of TNT only in smallest quantities for mining purposes. The CO percentage admissible after firing is extremely restricted because of the risk of firedamp [16]. Adding it to H.E. charges used in openpit mining is in principle, possible.
Military high explosives, however, prove to be extremely detonable and therefore they can be admixed to slurry explosive charges only in small quantities as the grain size distribution of the fired matter undergoes considerable changes.
Slurry explosive charges are compounds that can be transferred in pumps and consist of oxidation substances - in most cases ammonium nitrate, water and fuels that are used exclusively for civil purposes. It is most of all due to the applicable extensive safety approvals that only extremely small amounts of military high explosives could be processed in civil high explosive charges.

Thermal Disposal of High Explosives

Uncontrolled burning of propellants and explosives pollutes the air with various gases like NH_3, HCN and NO and produces also a lot of soot which is charged with condensed, highly toxic aromatic compounds (fig. 30, 31).

Controlled combustion of high explosives offers a series of advantages. Also compounds which are hardly separable can be burned. The energy contents of high explosives are in most cases overestimated. The table contains a comparison of the calorific value of high explosives and that of normal fuels (fig. 32). To reach the temperatures that are required for complete combustion, it is necessary to feed external energy.

This represents controlled burning in a rotary kiln with subsequent flue gas purification (fig. 33) which leads to high investment and maintenance cost due to the applicable safety and environment regulations that have to be observed. A high explosive combustion plant is running smoothly in Saxony / Germany since mid of 1994 [17].

Outlook and Assessment of Processes

Considering the individual processes applied for the conversion of high explosives results in a variety of technical and commercial aspects. Recycling in form of re-use is attributed very high importance by the society but has to remain affordable. This means that its application on cheap and dangerous products it is uninteresting, while it is considered for expensive high explosives like RDX.

Chemists' dreams of syntheses using annuated high explosives as educts fail because of the immense investments required to build facilities for the conversion of these substances and the utmost abundant variety of products found on the world's markets.

At first sight, the biological decomposition of high explosives appears to be a promising idea. It is, however, very expensive as it has to be based on pure substances and leads to product compounds that can hardly be separated.

An affordable way to annihilate high explosives extracted from annuated ordnance which can be achieved at short notice, is burning. The example "conversion of high explosives" shows that the desirable protection of the environment and preservation of resources is not always economically interesting and thus, feasible (fig. 34, 35).

List of Terms

Propellants consist of different high explosives and are sub-divided into:

Single base propellants which consist of mere cellulose nitrates (nitrocellulose) and a radical catcher to achieve aging protection.

Typical composition:

98% Nitrocellulose with varying nitrification degrees (11.6 - 13.3%).
2 % Diphenylamine as radical catchers for NO_2 radicals.

Main use: propellant for small calibered munition.

Double base propellants

The two high explosives cellulose nitrate (nitrocellulose) and glycerine nitrate (nitroglycerine) serve as energy carriers.

Typical composition:

50% Nitrocellulose
40% Nitroglycerine
1 % Copper salicylate (combustion moderator)
2,5 % Lead resorcinate (combustion moderator)
2 % 2,4 di-nitrodiphenlyamine (radical catcher)
4 % Di-n-propyladipate (additive)
0,5% Potassium kryolithe K3AIF6 (flame suppression)

Main purpose of use: rocket motors for military purposes.

Triple base propellants:

Three energy carriers define the formulation.

Typical composition:

50% Nitrocellulose
20% Nitroglycerine
20% Nitroguanidine
2% Akardite (di-phanylmethyl urea)
0,5% Potassium kryolithe (K3AIF6)

Main purpose of use: propellant for big calibered munition.

Composite propellants:

Contrary to the homogeneous single, double and triple base propellants, composite propellants are regarded heterogeneous. They consist of an oxidation agent, anorganic salt and a plastic component - in most cases this is a polyurethane which acts simultaneously as binding agent and as fuel. In many cases, ferrous oxides are used to serve as a combustion moderator.

Typical composition:

85%	Ammonium perchlorate
13%	Polyurethane / hydroxy terminated polybutadiene and isophorone di-isocyanate
2%	Ferrous (III) oxide

Main purpose of use: military and civil long range rocket motors (e.g. space shuttle propulsion).

Oxygen balance:

This represents the percentage in oxygen (in percent by weight) available during detonation which means conversion into H_2O, CO_2, NO_2, Al_2O_3 etc. As soon as the percentage in oxygen bound in the high explosive is insufficient to ensure a complete conversion this is regarded a negative oxygen balance; as soon as the percentage in oxygen is sufficient or presents a surplus, this is regarded a positive oxygen balance.

Examples:

TNT ($C_2H_5O_6N_3$)	-74,0 %
Nitroglycerine ($C_3H_5O_9N_3$)	+ 3,5 %
Ammoniumnitrate (NH_4NO_3)	+ 20,0%

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Conversion of High Explosives

——— Dreams and Reality ———

Dr. P. Wanninger

Rheinmetall
W&M GmbH
Unterlüß

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- Chemical Conversion
  - Commercial Aspects of Chemical Conversion
- Biological Decomposition of High Explosives
- High Explosive Recycling
- Use of Civil High Explosives
- Thermal Disposal of High Explosives
- Outlook and Assessment of Processes

Demilitarisation

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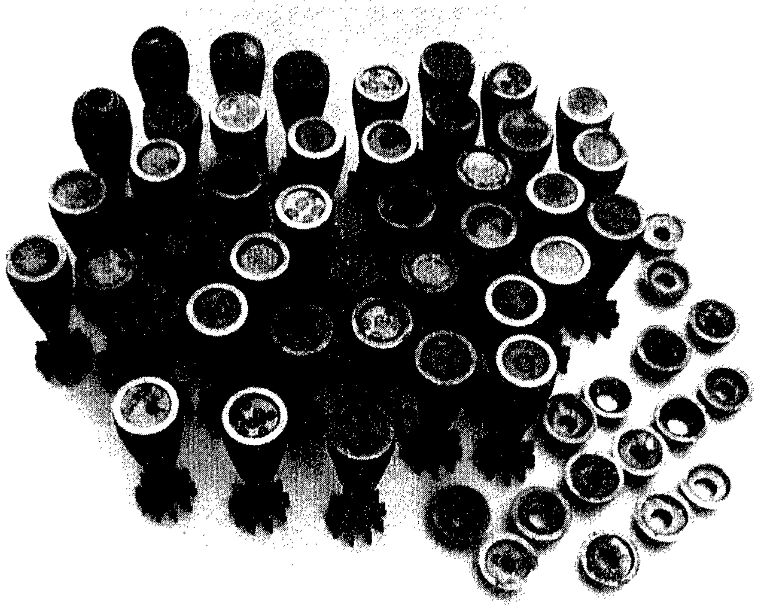
Water jet cut ammunition



Demilitarisation

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Formulations of Ammunitions

HE Charges	TNT	RDX	HMX	Binder
	15 -35	65 -85		
	15 - 25		75 -85	
		95		5
			95	5

Propellants

Single base	NC	Stabilizer	Graphite
	97,5	2	0,5

Double base	AP	NC	NG	Al	Stabilizer	Burning modifiers	Plasticizer	Binder
	0 - 20	45 - 50	30 - 40	0 - 15	1 - 2	3 - 5	5 - 10	
Composite	80 - 85			0 - 20		2 - 4	2 - 5	15 - 20

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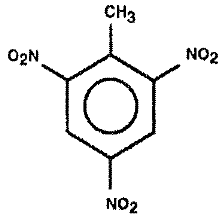
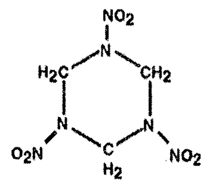
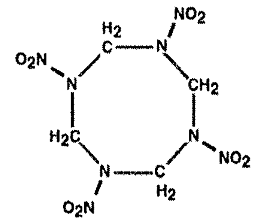
Explosives



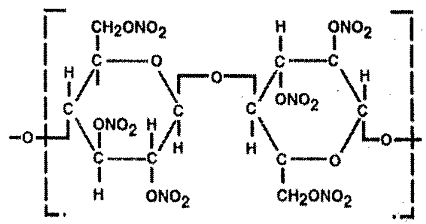
2, 4, 6 - Trinitrotoluol
TNT



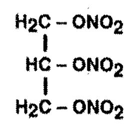
Cyclo 1, 3, 5
Trimethylen 2, 4, 6 - Trinitramin
Hexogen, RDX



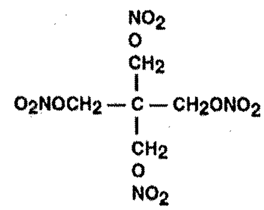
Cyclo 1, 3, 5, 7 - Tetramethylen
2, 4, 6, 8 - Tetranitramin
Oktogen, HMX



Cellulosenitrate, Nitrocellulose
NC



Glycerintrinitrate
Nitroglycerin
NG



Pentaerythrittetranitrate
Nitropenta
PETN

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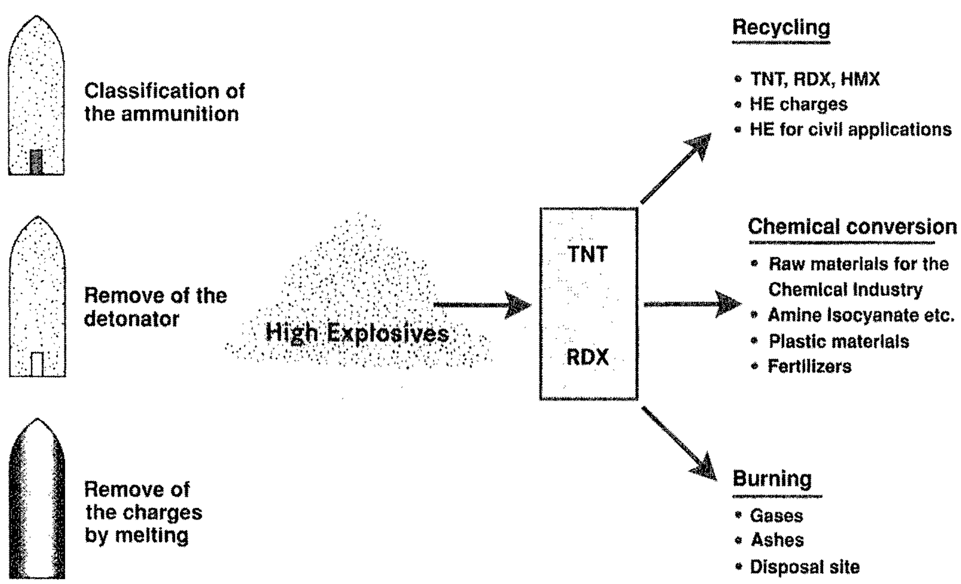
Demilitarisation



Chemical Conversion of Explosives

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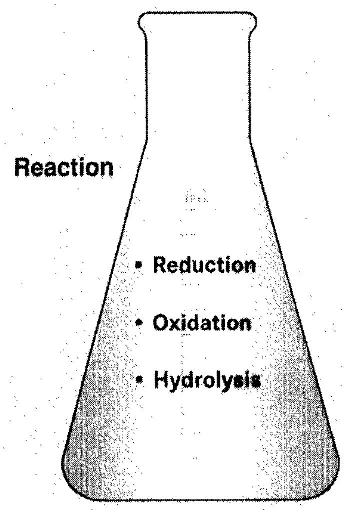

Chemical Conversion of Explosives

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Chemical Inertisation

$$\begin{array}{l} \text{H} \\ \text{HC}-\text{ONO}_2 \\ | \\ \text{HC}-\text{ONO}_2 \\ | \\ \text{HC}-\text{ONO}_2 \\ \text{H} \end{array} \quad \begin{array}{c} \xrightarrow[-\,NH_3\,-\,H_2O]{+\,\langle H\rangle} \\ \\ \xrightarrow[-\,C_6H_5-S-C_6H_5\;-\,NH_3\,-\,H_2O]{+\,OH\,+\,C_6H_5-SH} \end{array} \quad \begin{array}{l} \text{H} \\ \text{HC}-\text{OH} \\ | \\ \text{HC}-\text{OH} \\ | \\ \text{HC}-\text{OH} \\ \text{H} \end{array}$$

Chemical Conversion of Explosives

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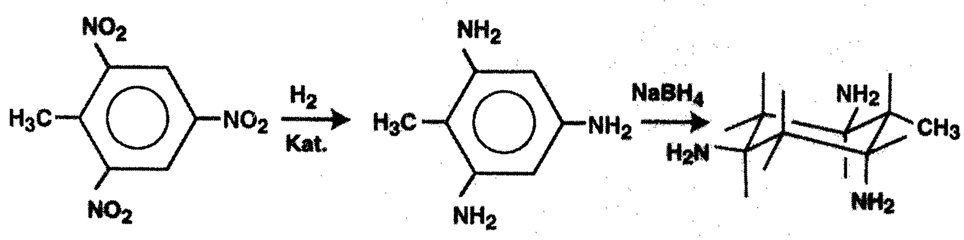
Hydrogenation of TNT



TNT TAT MeTACH

Chemical Conversion of Explosives

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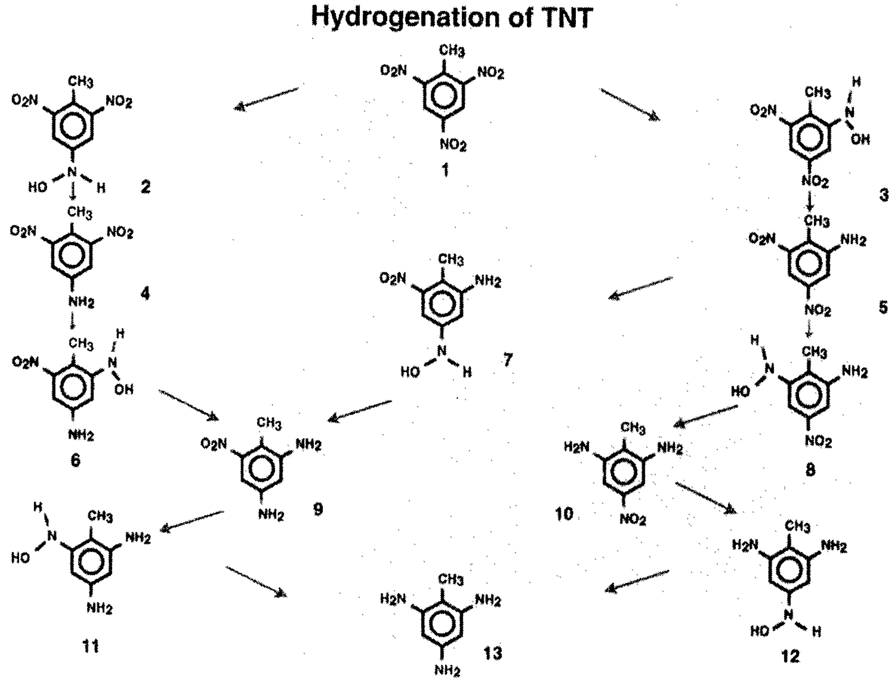
Hydrogenation of TNT



Chemical Conversion of Explosives

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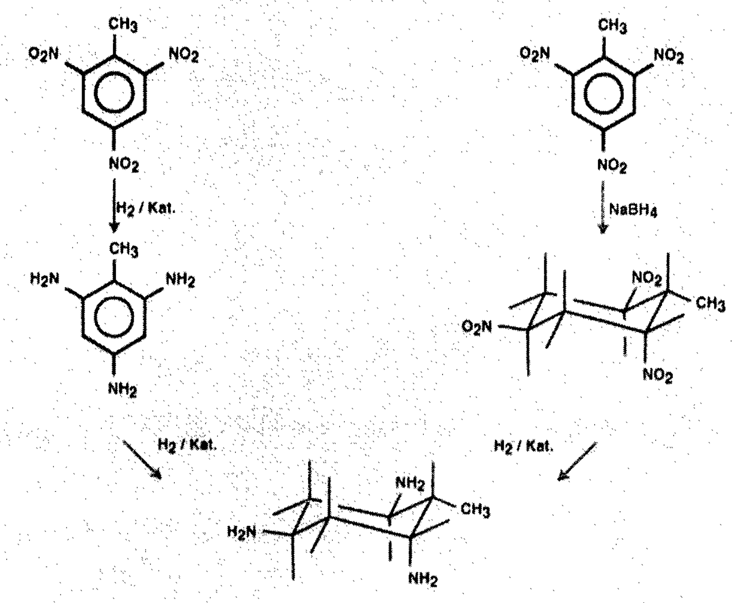
Synthesis of MeTACH



Hydrogenation of TNT

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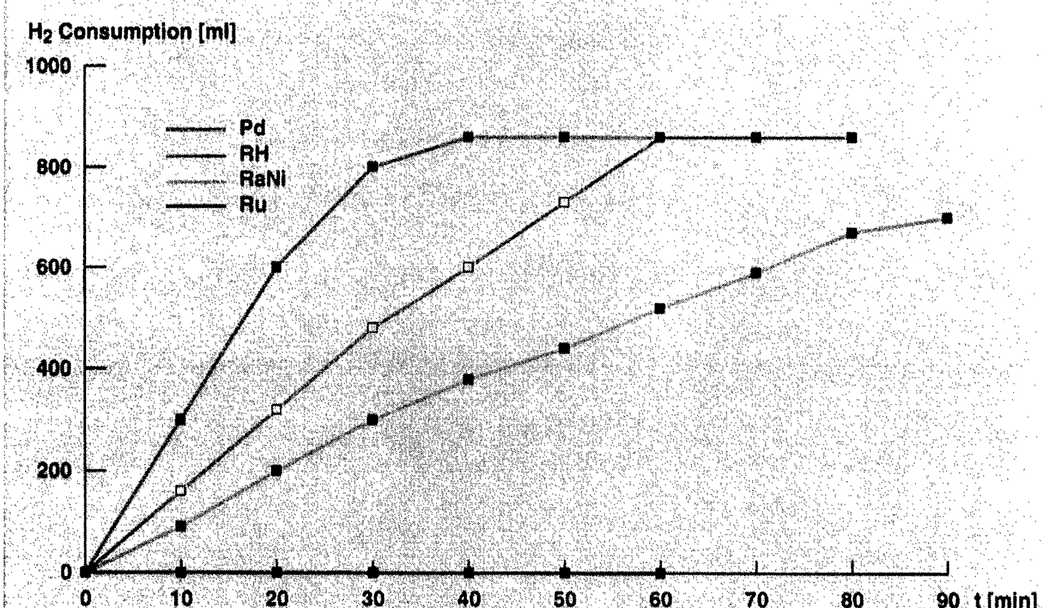
Influence of Catalyst



Chemical Conversion of Explosives

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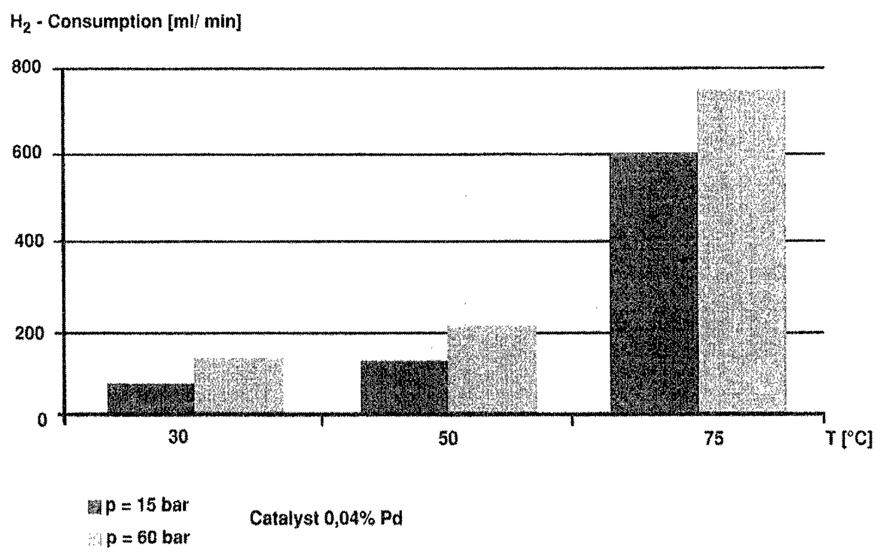
Hydrogenation of TNT

Reaction velocity vs. pressure and temperature



Chemical Conversion of Explosives

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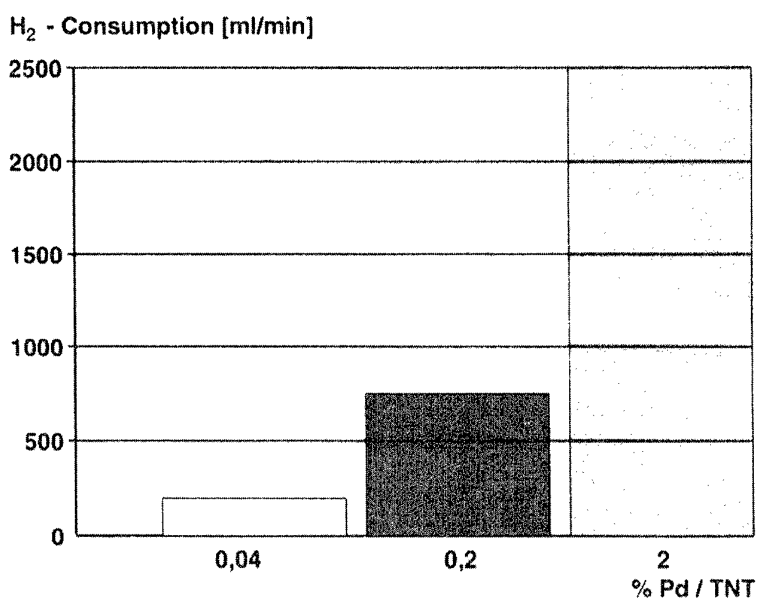
Hydrogenation of TNT

Reaction velocity vs. concentration of catalyst



Hydrogenation of TNT

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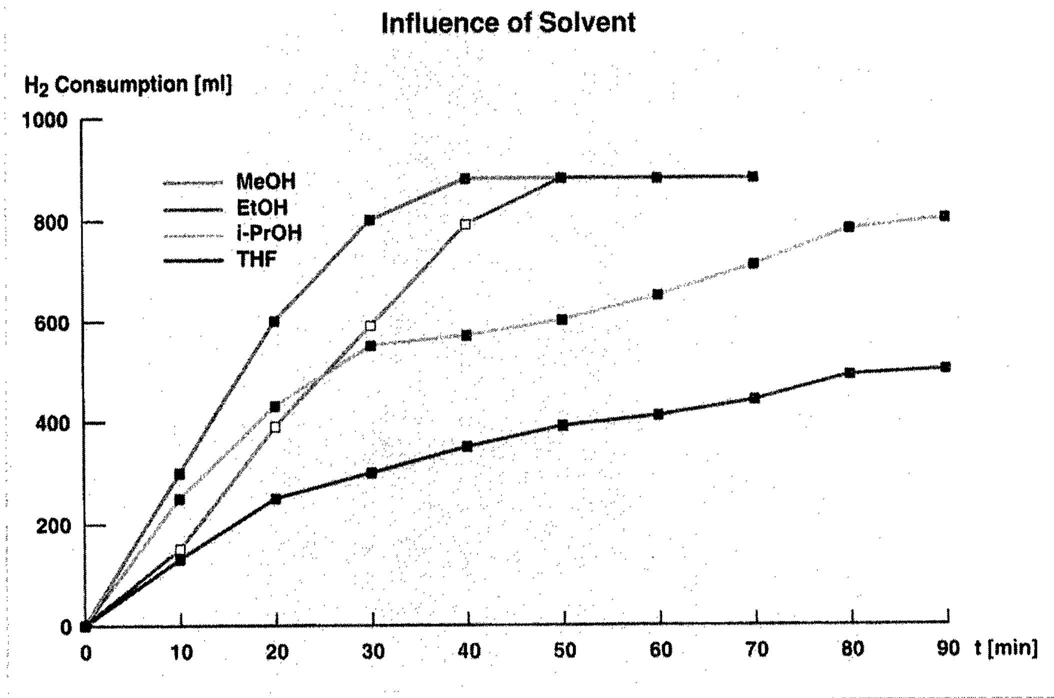

Hydrogenation of TNT

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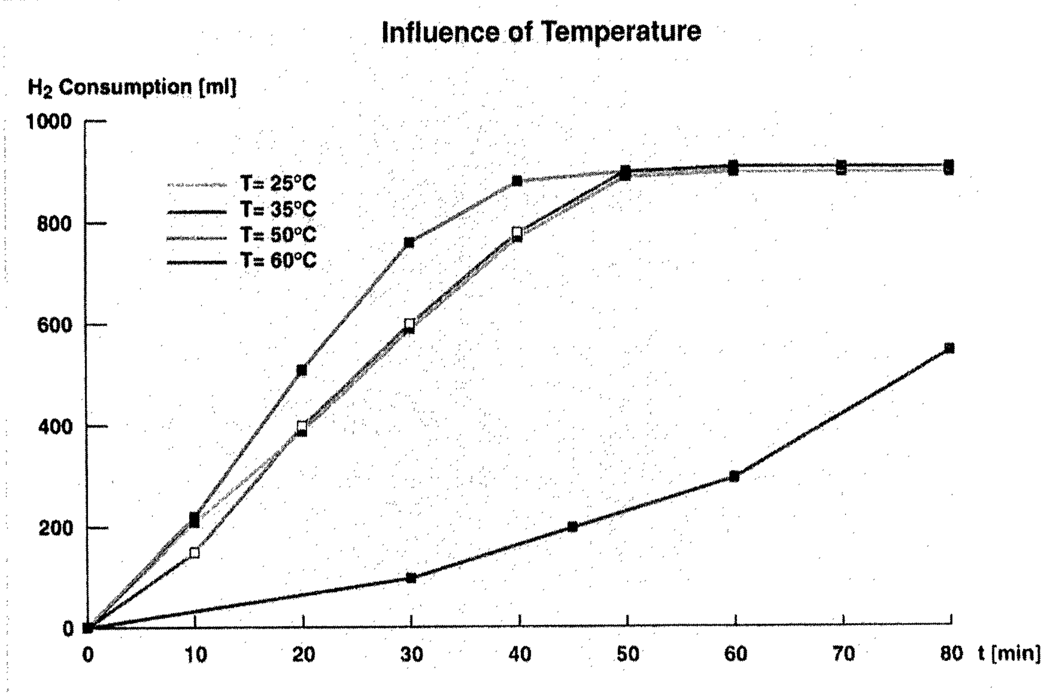
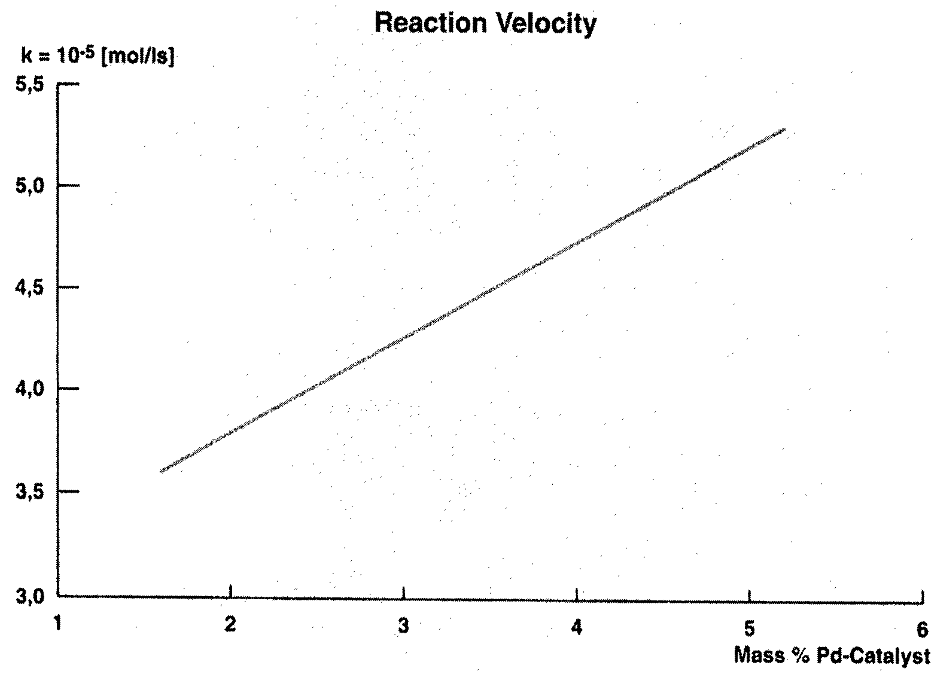


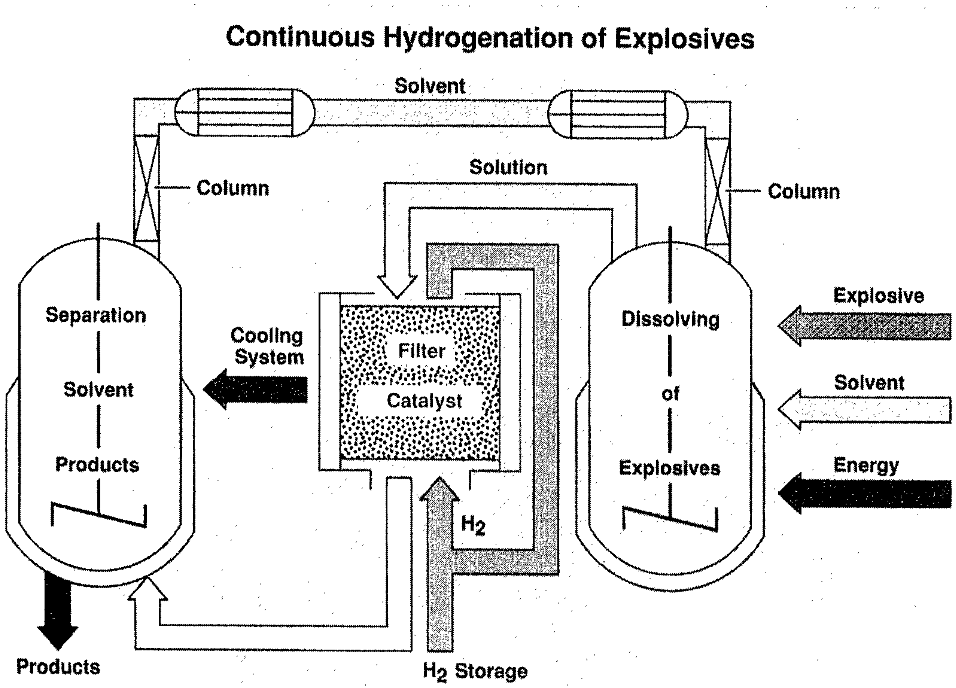
Hydrogenation of TNT

RHEINMETALL W&M



Chemical Conversion of Explosives

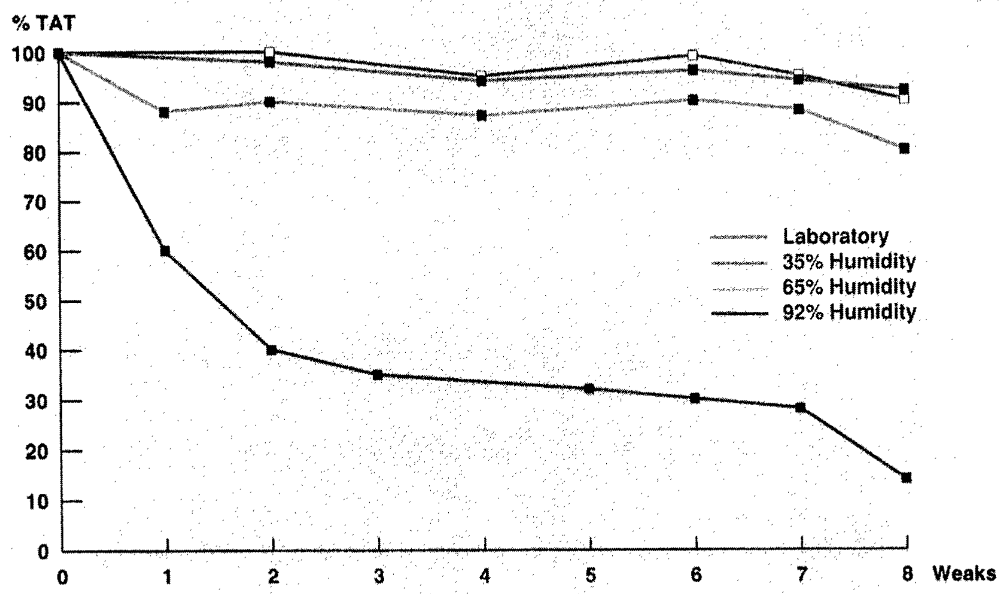
RHEINMETALL W&M



Chemical Conversion of Explosives

RHEINMETALL W&M

Stability of TAT at defined humidity



Chemical Conversion of Explosives

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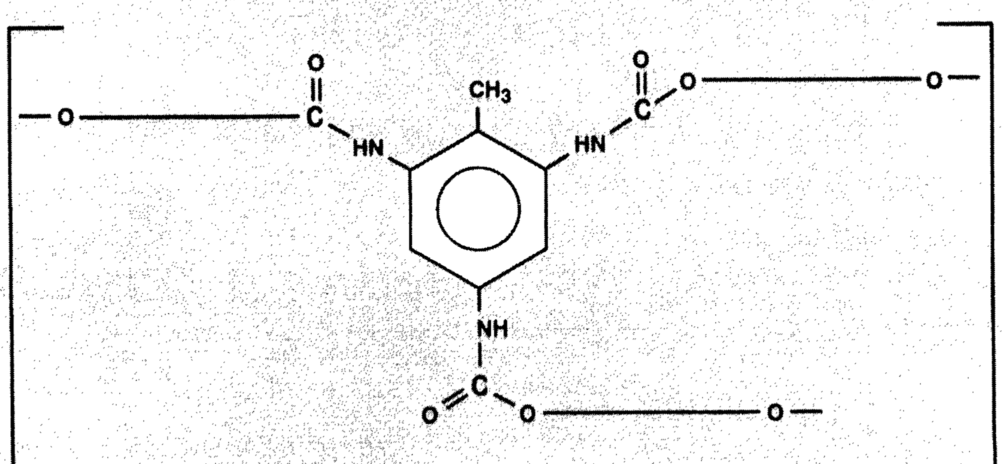
Polyurethane



Chemical Conversion of Explosives

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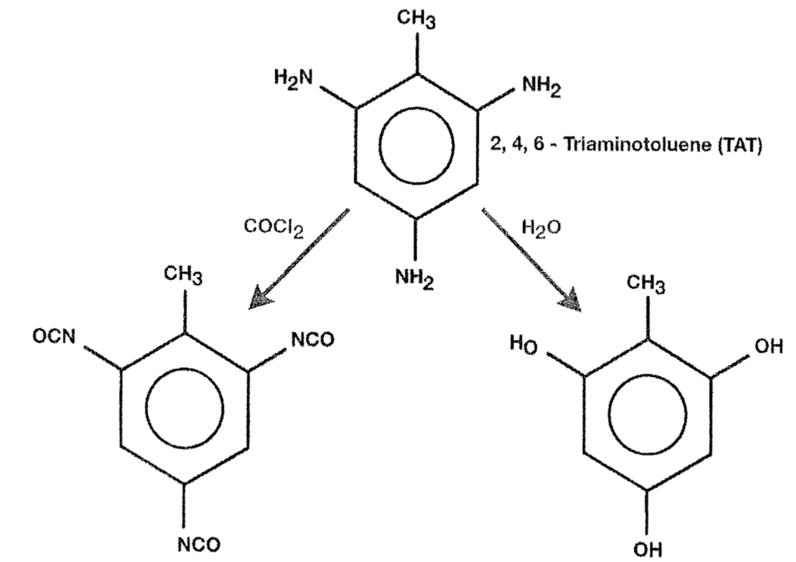
TAT Reaction Products



2, 4, 6 - Triisocyanatotoluene (TICT)

2, 4, 6 - Trihydroxytoluene (THT)

Chemical Conversion of Explosives

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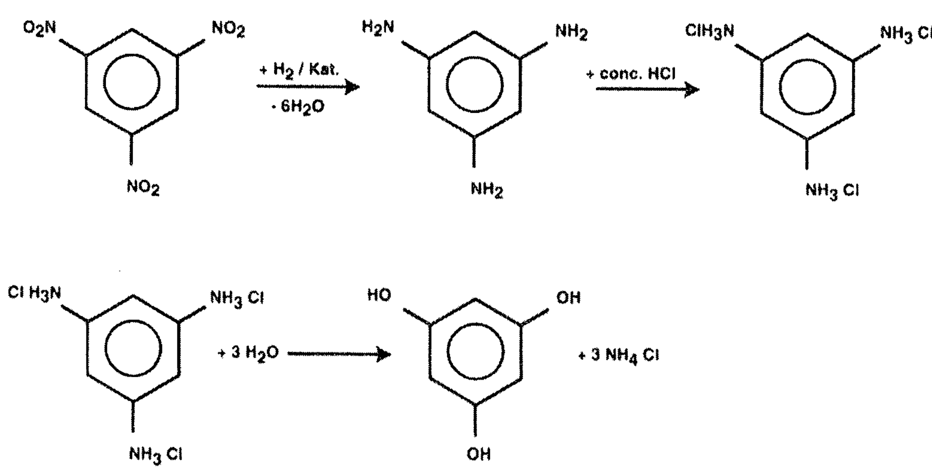
Synthesis of Phloroglucinol



Chemical Conversion of Explosives

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Use of Products

Raw material	Products	Evaluation
TNT	2, 4, 6- Triaminotoluene TAT 2, 4, 6- Triaminomethyl-cyclohexane, TAMC	Higher value products
RDX HMX	Formaldehyd, Methanol NO_X Nitrogen Ammonium	Waste
NC	Cellulose and Nitrate	Commodities
NG	Glycerine and Nitrate	Commodities
PETN	Pentaerythrite and Nitrate	Commodities
AP (NH_4 ClO_4)	NH_4 Cl	Commodities

Chemical Conversion of Explosives

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Conversion of Explosives

Raw material	Product	Annual production in USA and Western Europe 1990 [10^3t]
Dinitrotoluene	Toluenediisocyanate	870
TNT	Toluenetriisocyanate	0
NC	Cellulose	4 400
NG	Glycerine	550
PETN	Pentaerythrite	260
Nitratester	Ammoniumnitrate	14 800
TNB	Phloroglucinol	0,15

Chemical Conversion of Explosives

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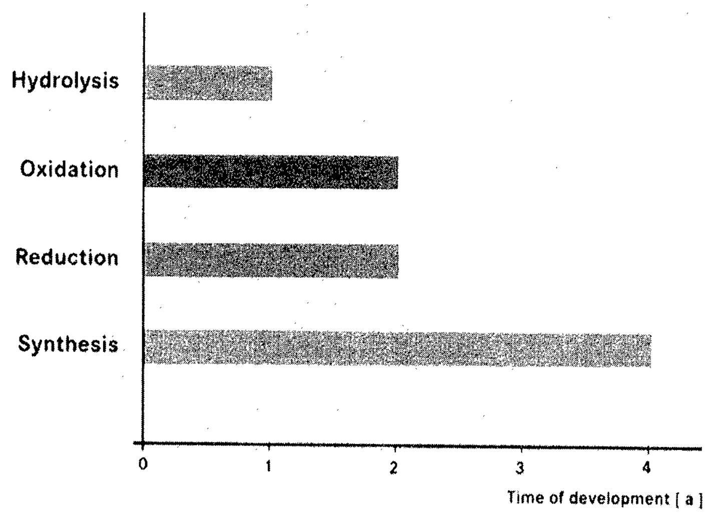

Chemical Inertisation

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Advantages

High explosives are valuable raw materials

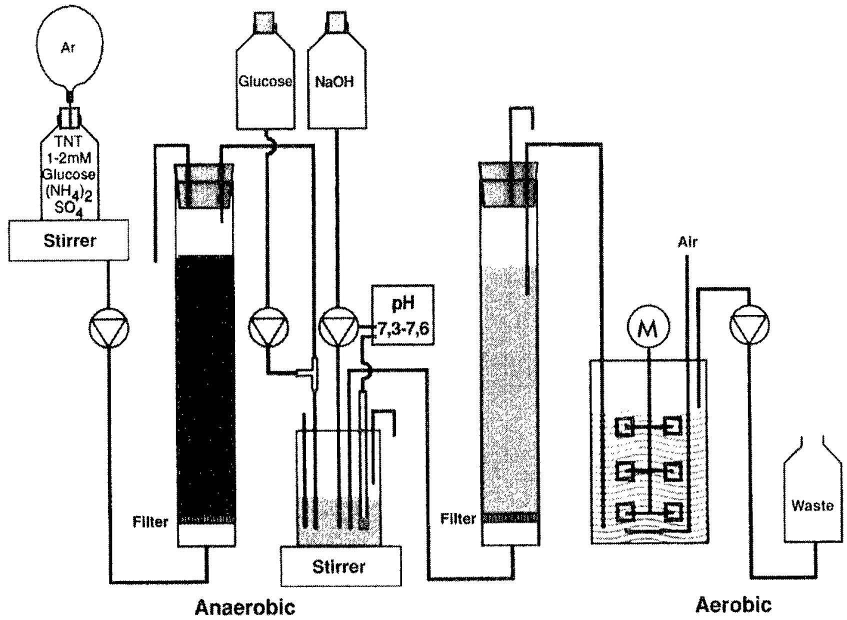
Synthesis of new products

Disadvantages

Biological Conversion of TNT

RHEINMETALL W&M

Laboratory Reactor



Max. Solubility 0,85 mM/l in H_2O/Geraniol 50/50

Biological Conversion of Explosives

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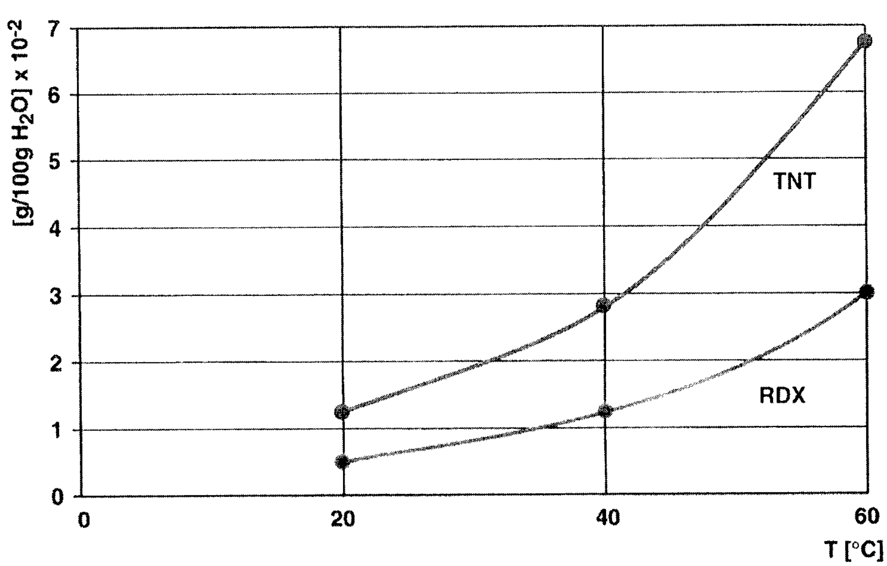
Solubility



Double base propellants

Typical formulation

50 %	Nitrocellulose
40 %	Nitroglycerine
1 %	Copper salicylate (combustion moderator)
2,5 %	Lead resorcinate (combustion moderator)
2 %	2,4 Di-nitrodiphenlyamine (radical catcher)
4 %	Di-n-propyladipate (additive)
0,5 %	Potassium kryolithe K_3AlF_6 (flame suppression)

Biological Conversion of Explosives
RHEINMETALL WAM

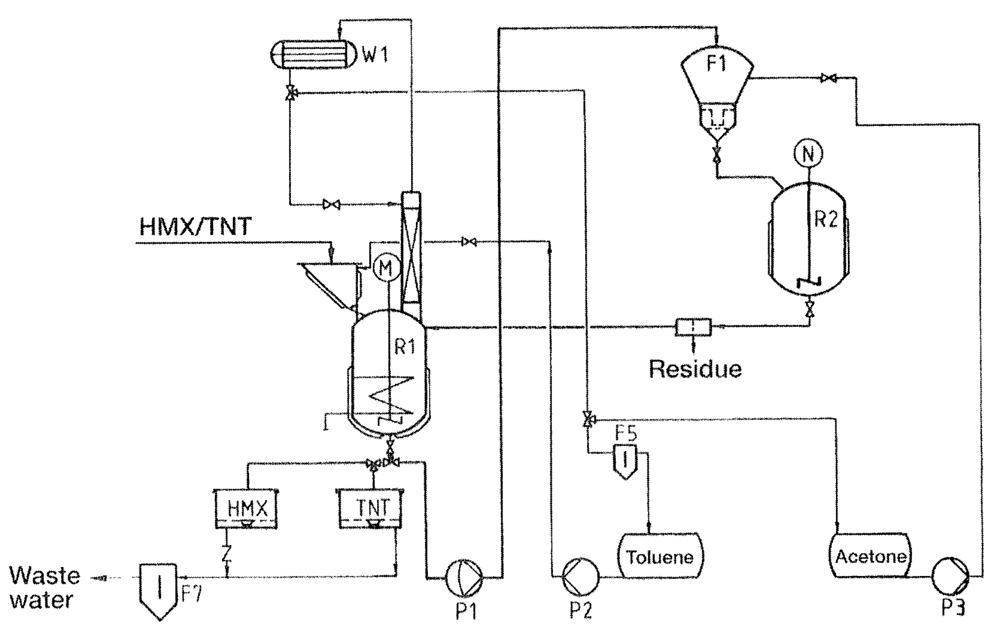
Problems

- Solubility in water
  - Big quantities of warm water are necessary
- Big quantities of glucose are necessary
- Toxicity of ingredients (e.g. coppersalts)
- Very toxic metabolites

Biological Inertisation

Advantages	Disadvantages
High public	Mostly pure raw materials required
Acceptance	Chemical steps
For contaminated soil	Minimum solubility required
For waste water	High energy consumption
	Longtime duration
	Yield
	Cost

HMX-Recycling

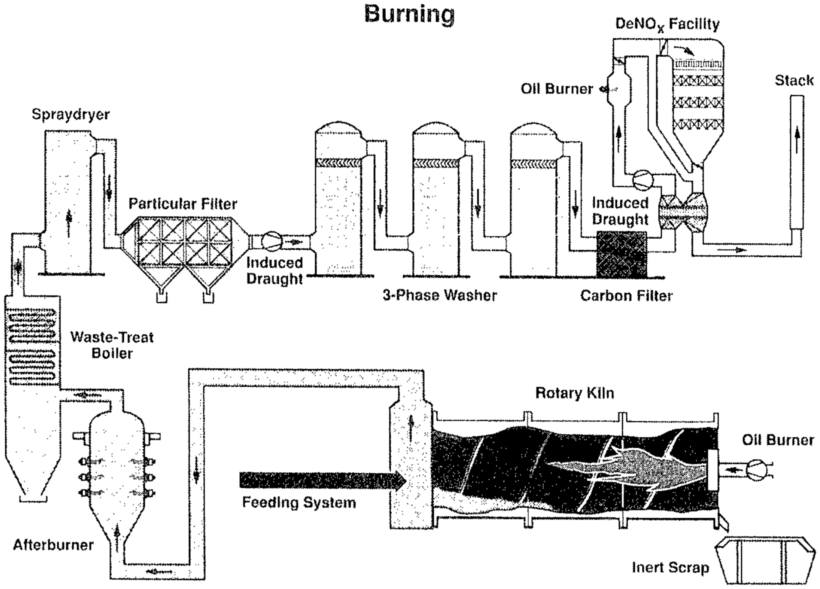


Recycling

Advantages	Disadvantages
Environment protection	Big invest necessary
Save energy	New qualification required
Save solvents etc.	Stock of raw materials necessary
Influence on quality of the product	High purity of raw materials required
Cost	

Disposal of Explosives

Burning



Oxygen Balance

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Nitrocellulose	**-28,6 %**
Tetryl	**-47,4 %**
RDX	**-21,6 %**
HMX	**-21,6 %**
TNT	**-74,0 %**

Thermal Decomposition of Explosives

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Combustion Enthalpy [kj/kg]

Explosives		Fuels	
TNT	15 146	Wood	15 700
RDX	9 560	Charcoal	31 000
HMX	9 883	Gasoil	43 960
NC	9 677	Ethylene	50 790
NG	6 761	Ammonia	22 360

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Explosivstoffentsorgung
Entwicklung der Genehmigungswerte

Stoffart	TA Luft 1974	TA Luft 1986	Grenzwerte für neue Genehmigungen
HCl	100 mg/cbm i.N.	50 mg/cbm i.N.	5 - 30 mg/cbm
$(NO)_X$	---	500 mg/cbm i.N.	300 mg/cbm
CO	1000 mg/cbm i.N.	100 mg/cbm i.N.	100 mg/cbm
Staub	100 mg/cbm i.N.	30 mg/cbm i.N.	10 - 30 mg/cbm

Thermal Decomposition

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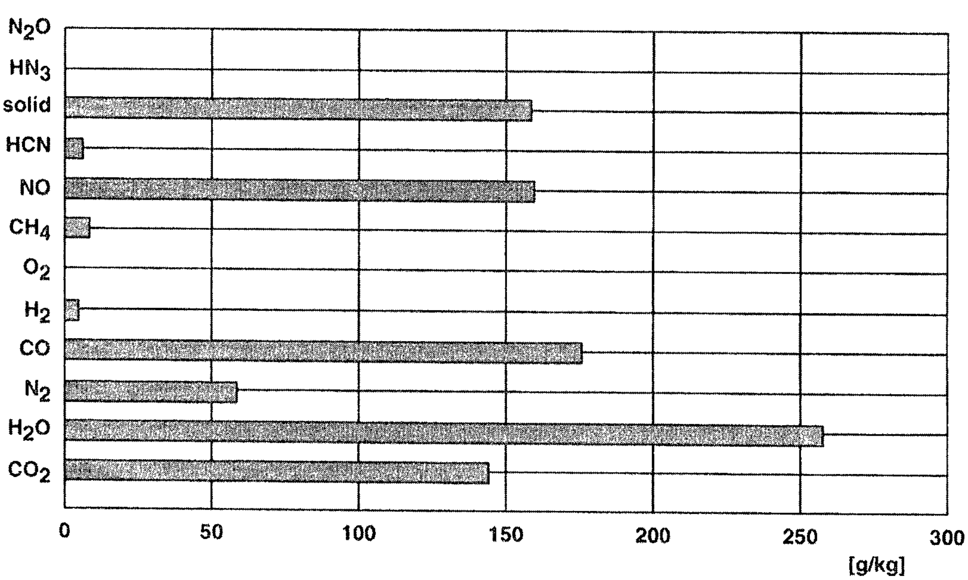
WEM

Gases of burned single base propellants



Thermal Decomposition

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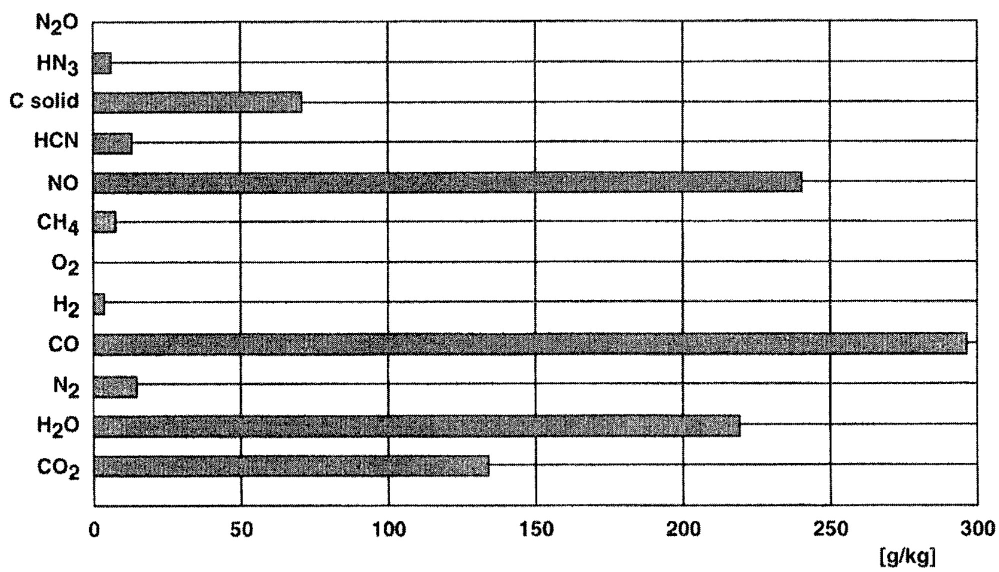
Gases of burned double base propellants



Thermal Decomposition

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Advantages	Disadvantages
Burning of unknown	Oxygen balance
Mixtures possible	Safety aspects
Less wastes	Pollution
High explosives are totally destroyed	Big investment

Evaluation of different processes

Material	Recycling	Chemical Conversion	Biological Degradation	Burning
HE charges				
TNT	+↓	+↑	+↓	+↑
RDX	+↓	0↓	0↓	+↑
HMX	+↑	0↓	-	+↓
Propellants				
NC	-	0↓	+↓	+↑
NG	+↓	0↓	0↓	+↑
AP	+↑	0↓	-	+↑

+ large scale production possible
0 feasible
- not feasible
↑ useful business management
↓ not useful business management

Disposal of Explosives RHEINMETALL W&M

Evaluation of different processes

Material	Recycling	Chemical Conversion	Biological Degradation	Burning
HE charges				
TNT / RDX	+↓	+↓	0↓	+↑
TNT / HMX	+↑	+↑	-	+↑
Propellants				
Single base	0↓	0↓	0↓	+↑
Double base	-	0↓	-	+↑
Composite	+↓	0↓	-	+↑

+ large scale production possible
0 feasible
- not feasible
↑ useful business management
↓ not useful business management

Latvian Approach to the Environmental Issues in the Military Area and Unexploded Ordnance

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Introduction

Following 5 decades since the World War II Latvia being occupied sequentially by Nazi and Soviet military powers suffered much from their military presence causing and activating also environmental problems into the places of direct location of German and Soviet troops and their military camps.

Extremely high density of former Soviet military units and institutions in Latvia (approx. 700) caused the situation that a lot of dangerous explosives, anti-personnel mines, different emissions, damaged and defected ammunition, other hazardous materials are still polluting vast Latvian rural territories the clearance and neutralisation of whom still challenge the Government being unable to allocate resources sufficient to these needs. Also problems concerning polluted water and soil in former Soviet military sites are not solved yet, then the storage and neutralisation of hazardous waste including dangerous chemicals, petroleum based compounds, rocket fuel, huge stocks of municipal waste left by Soviet army units, polluted sites in Liepaja former military seaport area etc.

Description

Serious reasons for such endangered status of things are found into internal Latvian difficulties.

For instance, no sufficient legislative basis still exists regulating the treatment of polluted military territories and fixing the division of responsibilities between local authorities, central Government and defensive forces or interior institutions.

Also in many cases no territorial planning processed in the communities thus making obstacles to any well-expected practical clearance intentions. There are no special rules and regulations adopted for specific sectors, territories or otherwise defined areas, and Latvian army units have to follow in general the same environmental rules as civilians.

General environmental legislation consists of the umbrella law on Environmental Protection (1991), special laws on Air and Water Pollution, Waste Management (including hazardous and municipal waste), Land Use law, Nature Conservancy law, Natural Resources Taxation law and some others.

Newly established Latvian Army units mainly are stationed in the same sites left by the Russian army after its withdrawal from Latvia in 1994. Still the number of Latvian army is limited, and they occupy only a small part of the former Soviet military territories.

Paper presented at the RTO SAS Symposium on "Approaches to the Implementation of Environment Pollution Prevention Technologies at Military Bases", held in Budapest, Hungary, 5-7 May 1999, and published in RTO MP-39.

Major part of sites are given in charge of local municipalities for civilian re-use, and they all inherited the mentioned pollution problems.

At present mainly stocks of municipal waste are put in order, still no remediation activities concerning soils and waters are carried out. In some of the military sites there are certain investigations and assessment of pollution made by foreign experts.

Still, there are no special environmental management plans prepared for military sites and bases as well, and only some proposals of making them are initiated.

General Objectives

Major objectives for the Latvian Government and National Armed Forces when solving this problem are as follows:

First, to put in order, demine and treat the territory of all former Soviet military sites in Latvian territory.

Second, to make a necessary legislative background and instructions regulating environmental issues in military area.

Third, to make the environmental management plans for Latvian military bases, armed forces units and training institutions.

Fourth, to provide the Latvian armed forces at all command levels with a sufficient number of environmentally educated and trained managers, to establish training and education system for military environmental managers, to introduce the environmental subjects in the military education and training curricula for all Latvian military personell.

Fifth, to provide close co-operation of military authorities with local and national environmental protection institutions and authorities, to ensure the wide public involvement and participation into solving of environmental problems in military area and controlling of militaries.

Former Soviet Military Sites

The Ministry of Defence proposes the following framework for the implementation of the first goal - to put in order, demine and treat the territory of former Soviet military sites in Latvia.

First, it seems necessary to make the environmental safety auditing of former Soviet military sites. This could be done by involving of national and foreign experts, by making of necessary investigations, by general risk assessment, by making of pilot auditing projects in some of sites (e.g., Adazi military base) etc.

Next step would be the Environmental Impact Assesment of the sites. This includes prioritizing of the sites according to their status, more detailed investigations and planning of necessary scope of works.

Planning of necessary further organizational steps should include the pilot project in Cekule former Soviet military base where a lot of endangered munitions and other unexploded materials are still located.

Then, the elaboration of special Governmental regulation should be encouraged dividing the responsibilities between Central Government and local authorities in the treatment of former Soviet military sites. This would be the umbrella rule regulating the overall division of

responsibilities, and the more detailed regulations should follow, i.e., on social security of field engineers directly involved in de-mining etc.

Further the relevant instructions for military units should be made how to handle the environmental protection issues, also financial instructions etc.

Governmental umbrella Regulation on the environmental treatment of former Soviet military sites should be made by Ministry of Defence, still the National Armed Forces Staff would be responsible for the more detailed documents.

Local authorities are responsible for the territorial (development) planning in the polluted territories in order to evaluate the scope of necessary works. This could be encouraged by registering of those local communities which have any polluted military site in their territory, by making of their territorial development plans, by further actions planning and by making of at least 2-3 pilot projects until the year 2001.

Afterwards, there will be the time for making of concrete treatment (de-mining) projects, and this should be organized by involving of necessary experts and provision of projects planning in strong accordance to the territorial plans made by local community. Elaboration and adoption of projects also should include the pilot project case study.

Plans of activities when dividing institutional responsibilities should include wide institutional involvement on the basis of costs- and responsibilities sharing, elaboration of tailor-made action plans for each institution, exact agreements on timing and action plan case studies, as well as solution of funding issues while involving national budget, local communities and private resources, and foreign assistance or credits as well.

Personnel, training and equipment issues must be solved by appropriate personnel resources planning, by training of the personnel, by identifying of necessary equipment, facilities, devices etc. Then, the tenders for equipment supplies must be announced and institutional strengthening of National Armed Forces field engineers corps should be provided.

Any international assistance to this initiative is very welcomed.

Legislative Background

For the second goal - to make a national legislative background and military instructions regulating environmental protection issues in military area, the first step would be the elaboration of MoD Environmental Protection Strategy already in 1999, as well as MoD and NAF Action Plan.

The Ministry of Defence must also draft the Governmental Regulation on Environmental Protection in Latvian Armed Forces, as well as ensure the working out of the specific regulations, rules and orders on environmental protection in military area later issued officially by the Minister of Defence or by NAF Commander.

Among them the following specific rules should be at the top:

1) on social security of field engineers or other military personnel involved in de-mining and similar activities.
2) on water pollution prevention in NAF bases and during the military exercises.
3) on soil pollution prevention in NAF bases and during the military exercises.
4) on air pollution prevention in NAF bases and during the military exercises.
5) regulation on noise prevention issues.
6) on nature protection in military area.
7) on hazardous and municipal waste management in military bases.

This proposed legislative background should be described in more detailed way in the mentioned MoD Environmental Protection Strategy and/or Action Plan as the first and more challenging document.

In-service instructions and financial instructions on environmental protection issues in NAF units should follow the NAF environmental protection action plans.

Environmental Management Plans for Military Sites

The appropriate elaboration of environmental management plans for Latvian military bases, armed forces units and training institutions also should follow the rules and procedures envisaged and fixed in the MoD Environmental Protection Strategy. One of the next steps would be the joint environmental protection Action Plan, appropriately coordinated among MoD and NAF.

Generally, it means that first the relevant legal background should be provided, when collecting of information and making of environmental audits in order to promote and facilitate the faster adoption of the Governmental Regulation on Environmental Protection in Latvian Armed Forces. One of the milestones to this could be also the specific NAF Environmental Protection Action Plan and/or 2-3 local pilot action plans in some of the units.

Further, at least several special environmental protection programs in military area should be elaborated, e.g., military waste management program, soil and water pollution prevention program, etc., as well as the specific projects (for instance, 2-3 territorial pilot projects) will be of high importance.

Afterwards, the prior designing of these environmental management plans should begin, including pilot project in Adazi military base. Such institutions as NAF, MoD and the Ministry of Environmental Protection and Regional Development would be involved.

Environmental Education and Training in the Military Area

When being tasked to provide the Latvian National Armed Forces at all command levels with a sufficient number of environmentally educated and trained managers, to establish training and education system for military environmental managers in Latvia, to introduce the environmental subjects in the military education and training curricula for all Latvian military personell, the MoD should make the following steps.

First, it is necessary to establish a relevant training and education system for military environmental managers in NAF structures. To do that, it seems reasonable to develop further the curricula of National Defence Academy, and other higher educational institutions as well, in order to include the environment in all those military training and education programs and plans.

Also the relevant textbooks and other audio-visual training means should be provided, the wide use of Western know-how will be very welcomed, experienced instructors and trainers must be involved.

Training of trainers would be the next and very important stage in all the educational reforming process, not only in the National Defence Academy, but also in other military training centers. Training abroad and case studies making are the necessary milestones when following that way.

Generally speaking the environmental subjects must be introduced into education and training curricula for all Latvian military personell. Of course, in addition to this the necessary

material background in the educational institutions must be developed, training of trainers processed and a lot of practical field exercises and case studies or pilot projects made.

Next, the regular updating of the mentioned curricula and training means should start according to the most recent needs and international experience. Participation of military staff and trainers into international training events, exchange and mobility of staff, cadets and officers should become a permanent and welcomed process, and not merely in the National Defence Academy, but elsewhere.

Publicity of Military Environmental Activities

To provide close co-operation of Latvian military authorities with the local and national environmental protection institutions and authorities, to ensure the wide public involvement and participation into solving of environmental problems in military area and controlling of militaries - that should become the MoD goal already in the nearest future.

Wide public involvement and participation in the treatment actions, environmental programs and projects in former Soviet military bases would contribute much to that purposes. Including of public environmental awareness constraints into the MOD's drafted defence concepts, programs and projects on environmental issues, will ensure the relevant public information activities on a regular basis.

First public awareness constraints should be included already in the MoD's Environmental Strategy and action plans. Further, whilst making special campaigns, informing public and the environmental institutions on the proposed military activities and also on pollution prevention measures being undertaken, the MoD will involve local authorities, national and local environmental protection institutions into its practical projects on environmental treatment in these military sites.

Later this should be developed into the regular co-operative frameworks, especially when linking MoD, NAF Staff and units with the local public and authorities, and environmental bodies as well.

Ensuring of public and civilian control on Latvian armed forces concerning environmental pollution prevention and restoring of environmental status should be followed by rapid and in-time provision of the due information on military activities both on a regular basis and, of course, in case of any accident. This should be a permanent duty of MoD and NAF, as well as their units and institutions.

Present Challenges

Basic challenge for the Ministry of Defence when following that way is the lack of skilled and well-enough educated military personell who could deal actively with the above-mentioned environmental problems.

Next challenge is too low capacity of the present training and military education system, as well as the lack of appropriate training facilities.

Also the fact that at present Latvian defence system has no sufficient number of instructors and teachers who could teach on the environment, thus the Western know-how could be transferred to Latvia much more than presently.

Then, the lack of funds and suitable equipment still challenge the Latvian MoD when trying to deal with this scope of works. Legislative background should be provided as soon as

possible ensuring, among other things, the due social guaranties for the military personell dealing directly with the de-mining, etc.

Future Visions

According to the drafted MoD Environmental Strategy, first of all, any former Soviet military site in Latvian territory must be put in order, demined and treated. This is both the financial and legislative problem which must be solved as soon as possible.

Second, the Latvian military bases, army units and training institutions should act in strong accordance to the territorial development and environmental management plans elaborated by local communities. Process of elaboration of those plans must be encouraged and supported both by Governmental and defensive structures.

Third, Latvian armed forces at all command levels should have a sufficient number of well educated and trained managers dealing actively with environmental protection issues. This seems to be both the personnel policy and education problem.

Next, the military personell has to undergo certain environment related training, and it has to have a good general knowledge in the environmental protection field. There the relevant international support is very welcomed.

And the last, Latvian militaries have to co-operate more closely with the local and national environmental protection institutions and authorities, as well as to ensure the wide public participation, awareness and support. It seems evident that the capacity of the MoD and defence forces is not strong enough to solve these problems alone.

Environmental problems in the former Soviet military sites

High density of former Soviet military units and institutions in Latvia (approx. 700) caused the following problems:

- a lot of dangerous explosives, landmines, different emissions, damaged and defected ammunition, other hazardous materials left by Soviet Army in Latvian territory
- polluted water and soil in former Soviet military sites
- storage and neutralisation of hazardous waste including dangerous chemicals, petroleum based compounds, rocket fuel, huge stocks of municipal waste
- polluted sites in Liepaja former military seaport area etc.

Environmental problems in the former Soviet military sites

Internal Latvian difficulties:

- lack of Governmental allocations sufficient to the clearance and neutralisation of unexploded materials
- no sufficient legislative basis regulating the treatment of polluted military territories and fixing the division of responsibilities between local authorities, central Government and defensive forces or interior institutions
- in many cases no territorial planning processed in the communities
- lack of special rules and regulations adopted for specific sectors, territories or otherwise defined areas (Latvian army units have to proceed in general the same environmental rules as civilians)
- lack of special environmental management plans for military sites and bases (only some proposals of making them are initiated)

General environmental legislation in Latvia

1. The umbrella law on Environmental Protection (1991)

2. Special laws:

- Air and Water Pollution law
- Waste Management law
(including hazardous and municipal waste)
- Land Use law
- Nature Conservancy law
- Natural Resources Taxation law
- some others.

Responsibilities for the management of the former Soviet military sites

- Latvian Army units mainly are stationed in the same sites left by the Russian army after its withdrawal from Latvia in 1994
- the number of Latvian army units are limited, and they occupy only a small part of the former Soviet military territories
- major part of sites are given in charge of local municipalities for civilian re-use

Present status

- mainly stocks of municipal waste are put in order
- no remediation activities concerning soils and waters are carried out
- in some of military sites there are pilot investigations and assessment of pollution made by foreign experts

Major objectives

- to put in order, demine and treat the territory of former Soviet military sites in Latvian territory
- to make a national legislative background and instructions regulating environmental issues in military area
- to elaborate the environmental management plans for Latvian military bases, armed forces units and training institutions
- to provide the Latvian armed forces at all command levels with a sufficient number of environmentally educated and trained managers
- to establish training and education system for military environmental managers in Latvia
- to introduce the environmental subjects in the military education and training curricula for all Latvian military personell
- to provide close and constructive co-operation of Latvian military authorities with local and national environmental protection institutions and authorities
- to ensure the wide public involvement and participation into solving of environmental problems in military area and controlling of militaries

Proposed Activities
to put in order the former Soviet military sites

I

First it is necessary to run an environmental safety auditing of former Soviet military sites:

- by involving national and foreign experts
- by making of necessary investigations and general environmental risk assessment
- by making of pilot auditing projects in some of sites (e.g., Adazi military base)

Institutions involved:

- National Armed Forces
- local authorities
- environmental protection authorities

Proposed Activities
to put in order the former Soviet military sites

II

To make the environmental impact assesment of these sites:

- by prioritising of the sites according to their endangered status
- by detailed investigations and planning of necessary scope of works
- by planning of necessary further organisational steps
- by making pilot project in Cekule former Soviet military base already in years 1999-2000

Institutions responsible:

- national and local environmental protection authorities
- National Armed Forces field engineers

Proposed Activities
to put in order the former Soviet military sites

III

To elaborate necessary Governmental regulations providing the division of responsibilities between the central Government and local authorities in the treatment of former Soviet military sites

- Governmental umbrella regulation regulating the division of responsibilities between the central Government and local authorities in the treatment of former Soviet military sites
- detailed regulations, i.e., on social security of field engineers directly involved in demining etc.
- instructions for military units how to handle the environmental protection issues
- financial instructions etc.

Institution responsible:

- Ministry of Defence

Proposed Activities
to put in order the former Soviet military sites

IV

To provide the territorial (development) planning for the polluted territories

- by registering of local communities having polluted military sites in their territory and by indicating the presence or absence of territorial development plans
- by making of these plans and further actions planning
- by making first 2 - 3 pilot projects

Institutions responsible:

- local authorities
- Ministry of Environmental Protection and Regional Development

Proposed Activities
to put in order the former Soviet military sites

V

To elaborate the treatment (de-mining) projects for these territories based on their territorial development plans

- by involvement of experts and projects planning in strong accordance to the territorial plans made by local community
- by elaboration and adoption of those projects
- by making of pilot project case studies

Institutions responsible:

- local authorities
- armed forces field engineers

Proposed Activities
to put in order the former Soviet military sites

VI

To elaborate the plans of activities, division of institutional responsibilities

- by provision of wide institutional involvement sharing the responsibilities
- by elaboration of separate action plans for each institution
- by agreements on timing
- by making of Action plan case study

Institutions responsible:

- National Armed Forces
- Ministry of Defence
- Ministry of Environmental Protection and Regional Development
- local authorities

Proposed Activities
to put in order the former Soviet military sites

VII

To solve funding issues when involving national budget, local communities and private resources, and foreign assistance or credits as well:

- by evaluating of existing funding possibilities and identifying of needs
- by preparation of expenditures lists, sending of requests to possible funding agencies
- by optimazing the financial planning
- by regular making of case studies

Institutions responsible:

- Ministry of Defence
- local authorities, etc.

Proposed Activities
to put in order the former Soviet military sites

VIII

To ensure necessary personnel, training and equipment:

- by personnel resources planning
- by training of personnel
- by identifying of needed equipment, facilities, devices etc.
- by institutional strengthening of National Armed Forces field engineers corps

Institutions responsible:

- National Armed Forces
- Ministry of Defence, etc.

Proposed Activities
to make the legislative background

I

To elaborate the Governmental Regulation on Environmental Protection in Latvian Armed Forces:

- by making in paralel the MOD Environmental Protection Strategy
- by making MOD/NAF Environmental Protection Action Plan

Institutions responsible:

- National Armed Forces
- Ministry of Defence
- Ministry of Environmental Protection and Regional Development

Proposed Activities
to make the legislative background

II

To make the specific regulations, rules and orders on environmental protection in military area issued by Minister of Defence or NAF Commander

- On social security of field engineers or other military personnel involved in demining and similar activities
- On water pollution prevention in NAF bases and during the military exercises
- On soil pollution prevention in NAF bases and during the military exercises
- On air pollution prevention in NAF bases and during the military exercises
- On noise prevention issues
- On nature protection in military area
- On hazardous and municipal waste management in military bases

Institutions responsible:

- Ministry of Defence
- National Armed Forces

Proposed Activities
to make the legislative background

III

To make the in-service instructions and financial instructions on environmental protection issues in NAF units

Institutions responsible:

- Ministry of Defence
- National Armed Forces Staff

Proposed Activities
to make the environmental management plans for military bases, armed forces units and training institutions

I

In order to make the environmental management plans for Latvian military bases, armed forces units and training institutions, it is necessary:

- To elaborate the Ministry of Defence Environmental Protection Strategy already in the years 1999-2000

Institution responsible:

- Ministry of Defence

Proposed Activities
to make the environmental management plans for military bases, units and training institutions

II

In order to make the environmental management plans for Latvian military bases, armed forces units and training institutions, it is necessary:

To elaborate the MOD/NAF Environmental Protection Action Plan:

- by making first the due legal background, including Governmental Regulation on Environmental Protection in Latvian Armed Forces
- by gathering of technical information
- by environmental auditing of military sites
- by making 2-3 local pilot action plans (at the units or base level) in 1999-2000

Institutions responsible:

- Ministry of Defence
- National Armed Forces Staff and units

Proposed Activities
to make the environmental management plans for military bases, units and training institutions

III

In order to make the environmental management plans for Latvian military bases, armed forces units and training institutions, it is necessary:

To elaborate the specific environmental protection programs in military area. (e.g., military waste management program, water or soil pollution prevention program, etc.)

Institutions responsible:

- Ministry of Defence
- National Armed Forces Staff

Proposed Activities
to make the environmental management plans for military bases, units and training institutions

IV

In order to make the environmental management plans for Latvian military bases, armed forces units and training institutions, it is necessary:

To elaborate <u>specific projects:</u>

- at least 2-3 territorial pilot projects in 1998-2000

<u>Institutions responsible:</u>

- Ministry of Defence
- National Armed Forces

Proposed Activities
to make the environmental management plans for military bases, units and training institutions

V

In order to make the environmental management plans for Latvian military bases, armed forces units and training institutions, it is necessary:

To make the environmental management plans for Latvian military bases, armed forces units and training institutions

- by making first the pilot project in Adazi military base in 1999-2000

Institutions responsible:

- Ministry of Defence
- National Armed Forces
- Ministry of Environmental Protection and Regional Development

Proposed Activities
to enhance the environmental education and training in military area

I

In order:

- to provide the Latvian National Armed Forces at all command levels with a sufficient number of environmentally educated and trained managers,
- to establish training and education system for military environmental managers in Latvia,
- to introduce the environmental subjects in the military education and training curricula for all Latvian military personell:

it is necessary:

To establish the training and education system for military environmental managers in NAF structures

- by developing the curricula of National Defence Academy, other higher educational institutions
- by elaboration of necessary textbooks, other audio-visual training means
- by wide use of Western know-how, involvement of necessary instructors and trainers
- by training of trainers
- by specialists training abroad
- by making of case study in National Defence Academy in 1999-2002

Institutions responsible:

- Ministry of Defence
- National Armed Forces Staff
- National Defence Academy

Proposed Activities
to enhance the environmental education and training in military area

II

In order:
- to provide the Latvian National Armed Forces at all command levels with a sufficient number of environmentally educated and trained managers,
- to establish training and education system for military environmental managers in Latvia,
- to introduce the environmental subjects in the military education and training curricula for all Latvian military personell:

it is necessary:

To introduce the environmental subjects in military education and training curricula for all Latvian military personell:

- by developing of necessary material background
- by training of trainers and instructors
- by practical field exercises
- by making of case studies and pilot projects in National Defence Academy in 1999-2002

Institutions responsible:

- Ministry of Defence
- National Armed Forces Staff
- National Defence Academy

Proposed Activities
to enhance the environmental education and training in military area

III

In order:
- to provide the Latvian National Armed Forces at all command levels with a sufficient number of environmentally educated and trained managers,
- to establish training and education system for military environmental managers in Latvia,
- to introduce the environmental subjects in the military education and training curricula for all Latvian military personell:

it is necessary:

To ensure the regular updating of the mentioned curricula according to the most recent needs:

- by participation of military staff and trainers into international training events
- by exchange and mobility of staff, cadets and officers

Institution responsible:

- National Defence Academy

Proposed Activities
to enhance the publicity of military environmental activities

I

In order:
- to provide close co-operation of military authorities with local and national environmental protection institutions and authorities,
- to ensure the wide public involvement and participation into solving of environmental problems in military area,
- to keep the civilian control on militaries,

it is necessary:

To provide the wide public involvement and participation in the treatment actions, environmental programmes and projects in former Soviet military bases:

- by including of Public Military Environmental Awareness Raising constraints into all MOD defence concepts and programs and projects,
- by public information activities on regular basis,
- by special campaigns
- by including public awareness constraints already into MOD Environmental Strategy and Action Plan for the years 1999-2008

Institutions responsible:

- Ministry of Defence
- National Armed Forces Staff and units

Proposed Activities
to enhance the publicity of military environmental activities

II

In order:

- to provide close co-operation of military authorities with local and national environmental protection institutions and authorities,
- to ensure the wide public involvement and participation into solving of environmental problems in military area,
- to keep the civilian control on militaries,

it is necessary:

To involve the local authorities, national and local environmental protection authorities in practical projects on environmental treatment activities in military sites

- by regular co-operation

Institutions responsible:

- Ministry of Defence
- National Armed Forces Staff and units

Proposed Activities
to enhance the publicity of military environmental activities

III

In order:
- to provide close co-operation of military authorities with local and national environmental protection institutions and authorities,
- to ensure the wide public involvement and participation into solving of environmental problems in military area,
- to keep the civilian control on militaries,

it is necessary:

To ensure the public and local authorities control on Latvian armed forces concerning also environmental pollution prevention and restoring of polluted environmental status

- by provision of information on a regular basis and in case of accidents

Institutions responsible:

- Ministry of Defence
- National Armed Forces

Future Visions - The Way Ahead

- All former Soviet military sites in Latvian territory are put in order, demined and treated

- Latvian military bases, army units and training institutions are acting in strong accordance to the environmental management plans of the territories they are stationed on

- Latvian armed forces at all command levels have a sufficient number of well educated and trained managers dealing actively with environmental protection issues

- Military personell have undergo a certain training and have a good general knowledge in the environmental protection field,

- Latvian militaries have close co-operation with local and national environmental protection institutions and authorities

Major needs

- Skilled personell
- Training and training facilities
- Instructors and Western know-how
- Funds
- Equipment
- Legislative background
- Social guaranties for the military personell

R^3 – Management in Demil Operations: Today and Tomorrow

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Abstract

Increasing environmental performance in munition demil during 50 years
After World War II surplus munition in Sweden was dumped in lakes, mines and in the open sea. During the late 60´s environmental concerns led to a ban on dumping. OB/OD therefore became the main method for demil of munitions. Growing environmental concern in the 70´s resulted in a small scale start of industrilized demil which during the 80´s steadily increased. During the 90´s demil of munition has been characterized by focus on recovery, reuse and recycling. This is due to a more rigorous environmental legislation coupled with an awakening environmental awareness in the Armed Forces and the discovery that an environmentally adapted demil process can be economically beneficial compared to OB/OD. A high degree of resource recovery and reuse ($R^{3)}$ is now obtained in the demil process, but some problems remain e.g. smoke and illuminating ammunition. Some approaches to handle these challenges are discussed.

The problem with the old dumpsites are also discussed: a survey has been performed in order to locate the numerous sites and measures are taken to investigate the risk for ecological effects. The dumped ammunition also constitutes a potential safety problem at some of the locations, both with regard to unintentional handling by the public and by potential detonation of unstable munition. (Some results from examination of dumped ammunition are presented).

Environmental efforts on a national level
The high focus on R^3 in demil operations in Sweden is in line with the political ambition for Sweden to be among the leading nations in the efforts to obtain a sustainable development of society. The Armed Forces and the Defence Materiel Administration are among the governemental authorities actively working to contribute to this strive. The work to implement an environmental management system according to ISO 14001 in the defence sector has started. The government has issued a command to the two authorities to jointly adapt guidelines for environmentally sound provision of defence materiel.

Vision
The main environmental objective concerning demil in Sweden at present is to totally eliminate the need for OB/OD to dispose of surplus munitions. This method must in the near future be replaced by even more optimated industrial processes focusing on recovering materials, explosives as well as metals, even in those ammunition components where we today still have some problems. State-of-the-art technology is a prerequisite to achieve fully environmentally adapted demil operations, as well as an innovative and life-cycle-oriented way of managing environmental aspects in all processes. International co-operation is of course a valuable tool for sharing knowledge and experience, which is necessary for achieving the best possible demil methods.

Paper presented at the RTO SAS Symposium on "Approaches to the Implementation of Environment Pollution Prevention Technologies at Military Bases", held in Budapest, Hungary, 5-7 May 1999, and published in RTO MP-39.

History of demilitarization in Sweden

Dumping ammunition

During the 1940s Sweden built up large ammunition stockpiles in order to keep a high military preparedness.[1] In the fifties and the early sixties, Sweden needed to get rid of the old munition in order to make room for new, modern munition in the storage facilities as new weapon systems were introduced. This had to be done quickly, as nobody knew how much time was left before the munition may have to be used in a conflict. Another problem was degradation of the smokeless gunpowder in the munition and copper azide corrosion in fuzes. There was no planning in advance of how to get rid of the old munition and nobody had given the problem much thought before, so in many cases it became an acute matter that had to be solved instantly.

Dumping the munition in lakes, mines and in the open sea was considered a fast, cheap, simple and safe way to get rid of the surplus and potentially dangerous muniton. There were no industrial demilitarization facilities yet and open burning/open detonation (OB/OD) was considered rather impractical in those days. The OB/OD technique wasn't very developed, so large pieces of ammunition was spread in the surroundings and there were fires which were difficult to fight, especially as there could also be some undetonated explosives left. Therefore dumping was often choosen as the preferred method and Nature was supposed to destroy the ammunition in only a few years time, just as it took care of all garbage from human activities.

How the dumping should to be perfomed was regulated in detail by the Armed Forces, though the instructions were a little different between the Army, the Navy and the Air Force. The Army prescribed the dumping to be done mainly in small forest lakes close to the depots in order to avoid transports. Old mines was also recommended, as they were often used as public dump sites for all kinds of waste. The Navy and the Air Force dumped most of their munition in the open sea. Today we have located about 100 sites where ammunition has been dumped.[2] It has been very difficult to find the deponies, as all the involved authorities of those days had different ways to register where the ammunition was dumped. The authorities have also changed names, ceased to exist and been merged several times during these fifty years, but we are still trying to locate more sites through studying old documents and talking to people who were around when the dumping took place.

Laws and public opinion start to influence dumping

The laws and regulations concerning dumping of ammunition were very scarce in the beginning. There was a law from 1918 forbidding dumping objects in water that could lead to formation of shoals that the boats could run aground. In the sixties there was a Government investigation about how fishermen could suffer economically from military activities, including dumping. It was decided that fishermen could claim for compensation if they were affected. this investigation also emphasized that dumping must come to an end and that industrial methods must be developed in order to take care of surplus ammunition.

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[1] Hanna Hörnström, Från dumpning till återvinning: Strategier för ammunitionsavveckling i Sverige 1940-1995, Swedish Defence Materiel Administration (Stockholm 1997).
[2] Lennart Wiman, Ammunitionsdumpning: förteckning över platser, mängder och vissa rester, Swedish Armed Forces (Stockholm 1995).

The newspapers wrote a lot about dumping of ammunition in the sixties. Scientists discussed how fast Nature would destroy the ammunition in the water and the conclusion was that it wouldn't take any longer than at most ten years, even in fresh water. Today when we take up ammunition that has spent fifty years at the bottom of freshwater lakes in sediments without much oxygen, we find that some of it is still as good as new and that it could actually still be used!

In 1964 dumping was forbidden in all freshwater lakes in Sweden except the biggest one; Vänern where it could go on for another four years. In 1972 dumping was forbidden in the open sea as well, as a consequence of an international agreement on the subject.

The need for industrial demilitarization facilities

During the forties and fifties, the manufacture of ammunition as well as assembling and storing it took place at the same place deep inside the mountains, and it was a very secret business in Sweden. In 1947, there was an accident i Mitholz in Switzerland where a large ammunition depot inside a mountain exploded and rocks and pieces of ammunition were thrown over a village nearby. This was a catastrophy for Switzerland and it happened only about a year after another accident of the same kind, when the ammunition depot i St Moritz exploded. The reasons for the Mitholz accident were never clearly understood, but it made the Swedish military attaché in Bern to write home and suggest to the Swedish authorities that perhaps it wasn't such a good idea to store ammunition in the same place as it was manufactured and assembled. The Supreme Commander was commissioned by the Ministry of Defence to investigate how this should be done in the future.

In 1955, the Supreme Commander concluded that a new engineering industry must be built where ammunition could be manufactured and assembled safely, while the depots was located separately and far from villages. He also mentioned that the industry could be used for demilitarization as well, as the necessary equipment for taking the ammunition apart was the same as for assembling it. It took ten years until a plant was built in Vingåker about 200 km southwest of Stockholm and another five years until the demilitarization started. Today it's Nammo LIAB AB that runs the facility.

LIAB AB was founded in 1953 and dealt with military pyrotechnics. In the sixties they expanded and started to manufacture all kinds of civilian products like washing machines and can-openers. Bofors bought the company in 1970 and the business changed again. Today LIAB AB is part of the Nordic ammunition company Nammo and specializes in environmentally adapted demilitarization of ammunition.

Open burning and open detonation

As mentioned above, dumping wasn't allowed any longer in the beginning of the seventies and industrial demilitarization at the Vingåker plant had just about begun, so the capacity was still fairly low. In 1971 there was another acute problem, as we had to make room in the ammunition storage facilities for a lot of new torpedos and the old ones had to be taken care of. The Vingåker plant couldn't demilitarize them and a lot of places were investigated where they could be destroyed by open detonation. An artillery range in Älvdalen in the north of Sweden was considered suitable and the torpedos were used to evaluate the range, to find out if the place could perhaps be used for more OB/OD in the future. The tests were considered successful and today we use Älvdalen for most of the OB/OD that is still done. As we don't consider it an environmentally sound method, especially as the emissions can't

be measured satisfactorly, we try to find other ways even for ammunition that is very difficult to demilitarize industrially today.

Environmental efforts on a national level

Today there is a vision of a sustainable development of society. It involves a global view of society where the consideration of ecological prerequisites is combined with a good economic, social and cultural development. The overall objective is to protect the environment and people's health, to use the earth's resources effectively and to reach a long-term sustainable development.

In Sweden a number of nationoal environmental objectives have been formulated and these state the level of ambition for environmental work in all sectors of society. In addition the various sectors have a general responsibility for the environment over and above the requirements of environmental legislation. The government wants authorities to act as forerunners in environmental work as they influence society by, inter alia, extensive purchasing. As a step in the work on integrating environmental consideration in the whole public administration, the Swedish Armed Forces (FM) and the Swedish Defence Materiel Administration (FMV) along with several other national authorities, are assigned by the government to implement environmental management systems based on ISO 14001.

In the environmental review performed by the Swedish Defence Materiel Administration (FMV), procurement of defence materiel was considered one of the most important environmental aspects. Through its procurement, FMV has a significant possibility to influence the market and control the development of more environmentally adapted products. To the defence industry a pronounced environmental profile is also an international means of competition. By taking the environmental aspects into consideration through studies and development work, it's possible to influence the design of the systems so that they are more environmentally adapted. This can also reduce costs for a system in a life-cycle perspective as, for example, toxic components may require special handling, authorisation and expensive winding-down measures.

Today's challenges

Sites with dumped ammunition

An extensive investigation in order to find all places in Sweden where ammunition was dumped in forties, fifties and sixies has been performed.[3] Hundreds of sites were located and most of them contain a lot of different ammunition and ammunition components all mixed together. A couple of them has been choosen in order to make a closer study of how the old ammunition behaves at the bottom of lakes, in old mines and out at sea when left unattended for sometimes more than fifty years.

At Dalkarlsberg 250 km west of Stockholm, about 900 tons of ammunition and explosives have been dumped in two water-filled mine shafts.[4] The future environmental status of the repository has been evaluated based on field investigations, chemical analyses, toxicity tests and hydrogeologcial computer modeling. No explosives or its degradation products were found in the wells, shafts or in the sediment from a nearby lake. It has been concluded that

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[3] Lennart Wiman, Försvarets miljöfarliga lämningar, Swedish Armed Forces (Stockholm 1995).

[4] Birgitta Liljedahl, Dumpad ammunition i gruvschakt Dalkarlsberg: En miljöriskbedömning, Swedish Defence Research Institute (Umeå 1997).

the explosives (TNT and lead acid) as well as the metals in the mine shafts will be completely realeased after about 2000 to 20 000 years, due to the diffusion from the dumped material. With regard to the relatively high dilution in the shafts, the concentration of released componentes int the water will be very low but not neglibible. The decision to be made is to let the ammunition stay where it is and install a system for monitoring the water chemistry in the shafts and evaluate methods for future water treatment.

Trials with taking up dumped ammunition have been done in a couple of places in Sweden. This ammunition has to be destroyed immediately for safety reasons, but it should still be done in a controlled environment where the exhaust gases can be cleaned. The method of taking up and destroying dumped ammunition at the dumpsite demands mobile units if it is to be done at several places in short time intervals. How to proceed with this kind of work is still under evaluation in Sweden.

R^3 challenges and international co-operation

There is some ammunition that for different reasons is difficult to demilitarize in an environmentally adapted way today. The most common reason is safety, as in the example with the dumped ammunition that has to be destroyed on the site very fast. There are also problems with certain materials in the ammunition, for example fully chlorinated smoke compositions (e.g. hexachloroethane) that may form dioxines during combustion. Rocket motors and primers are also considered problematic in Sweden today, as well as all kinds of pyrotechnic ammunition.

The Swedish Defence Materiel Administration has made experiments with disposal of hexachloroethane smoke generating hand grenades and illuminating shells at a civilian facility for hazardous waste treatment. The ammunition was incinerated in a rotary kiln together with other kinds of waste, the gases were cleaned and the ashes were put in a depony. These experiments were successful, even though the regulations around disposal of explosives are very detailed. The remaining issue is mainly an economical question, as heavily chlorinated compounds are tremendously expensive to dispose of.

Sweden and the U.S.A. have an agreement since 1996 for cooperation on environmental protection in defence matters, which has resulted in several different projects. One project focuses on environmentally adapted demilitarization of ammunition and alternatives to OB/OD as well as recource recovery and reuse (R^3) management. The project also includes monitoring, characterization and treatment of process waste and conversion products during combustion.

So far the project group has made a broad survey of demilitarization methods used today and identified common environmental issues associated with demilitarization. Alternative strategies and actions have been compared and some of the current questions are the molten salt destruction technology, the Munitions Items Disposition Action System (MIDAS) and continous monitoring of metals in combustor exhaust gases. At the moment data is exchanged on the molten salt technology for destroying explosives safely and environmentally friendly.

The Nordic countries also have an agreement to cooperate on defence environmental issues. Within this agreement there has been an information exchange meeting between the different national defence research institutes, where demilitarization of ammunition was a topic among others. All countries share the same problems, though the amounts of

ammunition may change. In this cooperation further exhange of ideas and know-how concerning demilitarization will take place.

Demil tomorrow - the vision

Resource recovery and reuse (R3) management is an important tool for the industry within the demilitarization market today. The ammunition to be demilitarized often contains potentially valuable metals, explosives and other componentes that can be recovered. Disassebly of ammunition in order to recover these components also facilitates for handling environmentally hazardous substances. It's very important to have a clear picture of the contents of the ammunition, which can sometimes be very difficult to obtain due to insufficient information.

The next step is to avoid future demilitarization problems with today's ammunition. The Swedish Defence Materiel Administration (FMV) is putting much effort into formulating environmental requirements for the new ammunition that is being developed and produced today. This has been identified as an important question of environmental awareness and training within the defence sector. FMV has an extensive environmental training program for all employees and also more specific training for key personel and top management.

The training for all employees consists of basic environmental knowledge and basic knowledge of the environmental management system ISO 14001. The environmental impact from the defence sector is of course a major issue in all training. The top management that controls the environmental management system undertakes more thorough training in ISO 14001 and how it affects the whole organization. The objective with all the training is to put the best possible environmental requirements considering technical performance and economical objectives in the whole acquisition process into use. This naturally affects demilitarization of ammunition as well as procuring new ammunition.

A life-cycle perspective in all defence procurement is also considered a major area of interest in Sweden. As the defence sector influences the defence specific materiel from development to recovery/disposal, the most important decisions concerning future handling are made already during the development phase. Therefore the Swedish government has decided that the Swedish Armed Forces and the Swedish Defence Materiel Administration have a *joint* responsibility for adapting the defence materiel to the environmental demands.

An ecologically sustainable society is a society in which human activity does not damage health, climate or ecosystems.[5] It is a society geared to renewable resources and conserving the resources available so that there will be enough of them for everybody, today and in the future. To achieve this, it's important that all sectors in society takes their responsibility. R^3-management in demilitarization operations is one small step forward in this direction.

[5] Ministry of the Environment, Towards an ecologically sustanable society, (Stockholm 1997).

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FMV

R3-management in demil operations: today and tomorrow

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Swedish Defence Materiel Administration

1

FMV

Environmentally sound defence procurement

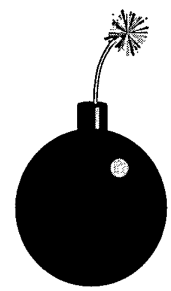
The Swedish Defence Materiel Administration and the Swedish Armed Forces have a joint responsibility for achieving a long-term and sustainable ecological development.

2

FMV

Remaining challenges

- Smoke compositions
  (e.g. hexachloroethane)
- Illuminating ammunition
- Rocket motors
- Primers



FMV

Demil R^3-vision:

-totally eliminating OB/OD
-using industrial methods focusing on resource recovery and reuse
-life-cycle perspective on ammunition: from development to demilitarization
-managing environmental aspects concerning demil within ISO 14001
-increasing international co-operation

Remedial Proposals for Former Military Lands in Georgia

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Introduction

The state of the environment in Georgia is influenced clearly by political and economic situation of the recent several years and the consequences of it are the pollution and disorder of natural equilibrium in different regions to a great extent.

The survey concerning the state of former military regions in our country is an initial attempt for the solution of one of the specific issues of this global problem.

After withdrawal of former Soviet Troops from the territory of Georgia and transmission of their former military bases to Georgian Government, in already heavily polluted country new problems have emerged. The question is the toxic and explosive substances, harmful waste, most of which is unfit and is not liable to utilisation. For example, near the coast of Black Sea, and in Eastern Georgia as well, more than thousand tons of liquid rocket fuel components as "Melange" and "Simine" are distributed without control, which creates significant risk for the population and environment. Some cases of their spilling without neutralisation into the Black Sea, leakage in soil and even explosion are observed. The reservoirs of the fuel are located near to Soganlugi, Meria, Chaladidi regions and Supsa pipeline construction. Part of them is deformed and part of them damaged. Because of expiration, the pressure in some of them has dangerously increased. According to former Soviet Army instructions "Melange" was neutralised with the water solution of caustic sodium and "Simine" with solution of bohr acid and after mixing with kerosene were burnt. The technological scheme is hardly acceptable from the environmental point of view. The new schemes for rendering harmless these substances are suggested which inevitably need special scientific processing.

Increase of radioactive background is observed in various regions of former Military Troops (Vaziani, Lilo, Abastumani, Senaki, Telavi, Poti, Kutaisi, Kopitnari). The radiation is caused by parts of damaged radiometric equipment with the source of radiation, which are distributed without control from rubbish heaps even to apartments and yards of the habitants.

Concerning this problem on October 9, 1997, by the order of President of Georgia the special Governmental Commission was established, whose objective is to study chemical and radioactive pollution in the territories transmitted to Georgian Governmental structures by the Soviet troops.

Because of deficiency of means and special equipment the commission has to work in extremely hard conditions. That influences a quality of work and increases hazards and disaster likelihood.

By the members of this commission in collaboration with representatives of International Agency of Nuclear Energy, the area for temporary storage of radioactive waste has been chosen, which has to meet the international norms and will be in action after completing of corresponding work. in

Again the lack of finances creates constrains.

One of the main reasons of these events is incomplete special form of the document concerning territory transmission, from one side to another and the absence of a specific law on the issue. The Laws of Georgia on Environmental Permit and on State Environmental Assessment do not contain specific articles for creating necessary documents and delineating responsibilities for each side.

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Apart from the Ministry of Environment and Natural Resources Protection, there are more than hundred environmental NGO's in Georgia. But in spite of this number, co-ordinated and purposeful work in this field is not carried out.

Due to this situation the group of Georgian scientists from Institutes of Geophysics, Physiology, Academy of Science supported by Ministry of Defense, Parliamentary Security Committee and the Department of Political-Military Affairs of Georgia express the willingness to conduct the special research and field works.

Future Collaboration

The contact with Federal Ministry of Environment, Nature Conversion and Nuclear Safety of Germany has been created to obtain the Risk Assessment Models applicable to the sites suspected of military and armament-related contamination. The German Federal Government started early with a comprehensive system to register, investigate, assess and clean up the sites left by Soviet Troops. The system Germany applied to deal with these sites was based on the following subsystems:

ALADIN:	Residual Pollution Data Information System
MEMURA:	Model for the Initial Assessment of Suspected Residual Pollution Areas
MAGMA:	Model for the Risk Assessment of Military and Armament Contaminated Sites
KOSAL:	System for Cost Assessment for Clean up of Contaminated Sites

These systems although specifically developed for the withdrawal of Soviet Troops from Germany are recognised and used for other sites as well. They stood the test in a very difficult phase and guaranteed an even approach to all sites, thus providing a sound basis for setting the priorities. The use of the system has substantially helped to avoid excessive cost for individual site characterisation and assessment.

After delivering these methodological materials to Georgians, German representatives kindly proposed collaboration in conducting the works in Georgia. The negotiations are held already on a governmental level and in the nearest future it will be possible to start working with assistance of this reliable and probated method.

Theoretical View on the Functional Capacity of the Biological Systems Under the Hazardous Impact

At the same time it would be very important to define the values of functional reserves of the ecological regulatory systems under the exogenic impact of the hazardous influence.

The different types of impacts accompany the systems during their existence and lead to the reconstruction, (reorganisation) directed to modification of systems' elements' functional level according to the changed biological and energetical demands. The systems adaptive action could be studied by using the natural laws of the controlled processes.

Adaptive reactions of the system are provided by the co-ordinated action of its autonomous and central regulatory links, in the different extent of realisation and its corresponding ways (monitoring, regulation and control) and depend on:

1. the biological properties,
2. the initial functional state,
3. the resistance of the system and
4. the type of the impact of different intensity (moderate, expressed, extreme), complexity (impulse, uneven, linear increasing) and duration (brief, long term and short)

For the investigation of the system's reactions on hazardous impact and for the foreseeing the likelihood of the regulation break-down and out-of control processes, we suggest to study the degree of activation of systems, considering specific heterogeneity of the responses on the impacts of varying intensity.

Characteristic feature of the biological parameters is their variability due to changing conditions.

There exist some defined range of equilibrium for the system, within the frame of which location of parameters is relatively indifferent from the position of the system's integrity and normal functioning.

Under the moderate impact on the system the values of its parameters can fluctuate. The notion of standard deviation was chosen as a quantitative exponent, which can judge (evaluate) the character of fluctuation of parameter's values. It reflects the measure of dispersion of the separate values of the parameters related (referred) to the average value and is the average square of deviation of variants from mean values of given multitude.

The permanent fluctuation of the parameter's values yields non-zero standard deviation in the background state of the system and the possibility of its increase under the impacts.

The moderate impacts can lead to uni-directed fluctuation and the parameters new value can change the position by level within equilibrium range.

The expressed impact, which however does not affect the linear functioning of the system, could be compensated by the system itself, forcing the values of its parameters back in the frame, what more in any point of it. At the same time, the impact which leads out the value of parameters from the equilibrium range, transmits the system from the monitoring to the regulatory level, activates other regulatory system, which start to regulate tightly the values of parameters, that brings to the abrupt decrease of fluctuation and, hence, of the standard deviation.

Perhaps, only under extreme and subextreme impacts, after exhaustion of the functional abilities of the system, the increase in variability is observed again, which however does not prevent the future decrease of the standard deviation after activation of another, more capable system, or the formation of the new functional one.

Thus, there exists the general biological rule, according to which the activation of the regulatory systems leads to the decrease of the dispersion of the regulating parameters' values, decrease in the entropy and removes the uncertainty from the regulatory system.

This approach can help to solve the important task: the evaluation of the activation of the regulatory system, which works on holding back controlled value of parameter.

From the position of system reaction prediction in response to the impact, evaluation of these reactions by means of the dispersion analyses has number of advantages:

1.The increased reliability of the system's background state evaluation.
2.The possibility of drawing-up the prognostic line "intensity-reaction" for the impacts of different intensity.
3.This approach can significantly alter the perceptions of the values of threshold and permissible limited impacts and concentrations.
4.To make precise the values of the regulatory reserves and the system state equilibrium ranges.

As to the organisational suggestions, we are going to draw attention of investigators from different scientific institutions and research laboratories to this issue, to make attempts to focus their interests on this problem and involve them in research work according to their field of study and the objects of investigation.

According to problem priority and in case of availability of the finances, it will become possible to give temporary jobs to outstanding specialists, to co-ordinate the monitoring of the situation and work on the proposals for the amendments to Georgian Laws on the basis of reliable data.

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RADIOACTIVE WASTES IN A CONVENTIONAL MILITARY ENVIRONMENT

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Although other types of radioactive waste exist, it is intended to concentrate on wastes originating from the process of luminising military equipment as this constitutes the bulk of the waste. The talk outlines the way radioactive materials have been used for the purpose of luminising United Kingdom military equipment, from its first use during the First World War, through its expansion of use in the Second World War to the current situation. The way in which the radioactive materials have been used, and the type of radioactive material used, is explored as are the consequences of the luminising of military equipment.

It is appropriate to consider at this time why military equipment has been luminised. Primarily, it is to provide a PERMANENT light source in all field conditions. Additionally, the weight carried by any individual Serviceman can be reduced, as no batteries are required. With the development of better power cells, the weight considerations have diminished since the last World War, but it is nevertheless true that every little weight reduction is a gain. Finally, the light level from luminised equipment is low; sufficient to enable the equipment to be used, but not so bright that night sight is destroyed.

When luminising first began, the radioactive material used to provide the energy for the light source was radium, commonly referred to as radium-226. Some radiations from radium are highly penetrating. The radium itself has a long half-life and takes a long time to be cleared from the body if it has been taken in. It also gives off radon, a radioactive gas which readily diffuses and consequently can spread radioactive contamination. More positively, items luminised with radium did not need to be re-luminised frequently due to the very long half-life (define half-life if thought necessary) of the radioactive material, and the radium itself was very environmentally stable.

Recognising the contamination problems from radium, and its environmental toxicity and persistence, the UK MOD substituted a less radioactive material for luminising compounds in the late 1960s. This was a radioactive metal, promethium-147. The use of promethium proved unsatisfactory as the radiation energy from it was much reduced, leading to lower light intensities, and the half-life was very short. Both of these properties, while satisfactory from an environmental point of view, lead to increased maintenance and reduced operational effectiveness.

The radioactive material of choice for luminising is tritium, the radioactive form of hydrogen. It has a sufficiently long half-life so that re-luminising is not often required and is not particularly toxic. Initially used as a paint, which was found to flake off and cause contamination in the luminised equipment, the commonest method is the use of Gaseous Tritium Light Sources. These have tritium contained in glass envelopes which are internally coated with the luminising compound, which allows easy replacement of these light sources while reducing the risk of spreading radioactive material to the environment.

They proved to be a considerable improvement over the use of paint, but are quite fragile and require protection within the equipment. Should the glass envelope be broken, the tritium itself is environmentally mobile and rapidly diffuses to the extent it can be no longer found. However, tritium contaminated fragments of glass will remain and require proper disposal.

From this data, it can be seen that toxic materials can be replaced by less environmentally harmful alternatives and that the radiation industry and UK MOD have been carrying out this strategy for many years. However, there remains the legacy of toxic materials used in the past. Primarily, this

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legacy consists of sites contaminated with radium, as the promethium has all decayed to levels which are no longer detectable, and any tritium released is rapidly dispersed in the environment.

Sites become contaminated with radium due to the way it was used in the past and the way earlier site remediation was carried out. Radium does not constitute the only contaminant, and frequently heavy metals, ash and asbestos are also found. Indeed, a recent decontamination was undertaken on a site which had been used for the disposal of "mustard gas" test kits dating from the Second World War.

In the past, radium was, for financial reasons, a tightly controlled substance. Its full toxicity was not recognised at that time. Consequently, radium paint was stored in secure conditions but any waste from the luminising process was dealt with as if it were non-toxic material. This normally resulted in the waste being burned on the site in uncontrolled conditions and the ashes and debris resulting from this disposed of in the site dump. This dump was often a small landfill pit, and was also used for the dumping of many other materials, including batteries.

Contamination of the site also arose from the normal luminising work carried out. Because radium was not considered toxic, control of the workplace was poor. Consequently, radium escaped from the luminising buildings into the ground outside. This was often as a result of leaving material on windowsills or failing to wash properly before leaving the building.

Finally, when luminising work ceased, there was a requirement to put many of the buildings to alternative uses. Some remediation of the buildings was therefore required. This was done on the basis that it must be sufficient to allow the re-use of the building; it was not necessary to totally remove all the radium. This was in keeping with the accepted national standards and practices of the time, but did not lead to a full remediation. Again, the waste produced from this form of decontamination was burnt and buried on the site. Indeed, one person involved with this work had a habit of burying the radium contaminated ashes in the flowerbeds associated with the Officers Mess!

Problems associated with the decontamination and remediation of sites contaminated in this way are best considered from a practical example. The project chosen for this is the decontamination of a site in London.

A brief history of the site is that a building on the site was used for the radium luminising of military equipment. Once luminising ceased on the site in the 1970s, the building was partially decontaminated but was not required for operational reasons and was therefore only used for storage. Radium remained in the fabric of the building.

During the late 1980s, it was decided to bring the building back into operational use and a project to decontaminate and refurbish the building and its immediate environs was initiated. The Works Phase was carried out in 1989/90.

An extended survey of the site carried out following the building refurbishment identified that additional contamination was located in a landfill area and in the "dell stream and ponds". Contamination left in place as the usage of these areas was as fitness training for soldiers, which involved no disturbance of the ground. However, new use for the site was proposed in 1994 and this led to a requirement to decontaminate the landfill and dell areas.

This project was completed in 1996 and only this last phase is considered further.

Landfill site is a rectangle bordered on its long sides by a Cemetery and the operational side. The former Gatehouse and the dell stream and ponds border the narrow sides. The site was narrow but several hundred metres long and was extensively contaminated. Although contaminated, the contamination was not present at levels which constituted a hazard to personnel working on the surface. Only if the ground were disturbed would a hazard arise.

Note the works in progress; eventually, contamination was found in the landfill to a depth of 5m. Main works access was along the border between the remediation site and the Gatehouse. Some screening for noise/nuisance was required. Photograph is from early in the project as decontamination began at the end where photo taken from and worked back towards the Gatehouse.

Screening between contaminated area and the Gatehouse. Note the narrowness of access. Also note that his back door was less than 3 metres from the screen.

Turning to the dell, this begins at the edge of the landfill site and continues northwards toward the Thames getting wider all the time. It is heavily wooded and was used for the training of soldiers.

A stream emerges from the landfill area and flows down the dell to join with a stream emerging from the local housing estate. The joint flow then forms a series of interconnected ponds of various sizes. Pond 4 is the largest and furthest down the dell and was extensively fished. Ponds 1 & 2 were found to contain contaminated silt. The series of ponds had acted as settling tanks which prevented the contamination from reaching pond 4. This meant that fishing was only required to be banned for the period surrounding the actual remediation works. This was considered necessary even though steps had been taken to prevent any contamination reaching the lower ponds. Note that, as mentioned before, the radium was in an insoluble form (as demonstrated by laboratory tests) and was not environmentally very mobile; its spread to the dell is a consequence of "wash out" from the landfill area.

Decontamination of pond 2 required the draining of the pond and removal of the silt. Here the pond is shown as part drained. Silt was very soft and all had to be removed eventually. This proved to be a layer 1.5 m deep and the refilled pond was left in a much improved state.

Considering the complexity of the site, how was a successful remediation achieved? The internal procedures are not detailed, but the key areas identified.

Contract must: Define End Point
Define Site
Define Responsibilities and Lines of Communication

Regulators have to be involved at an early stage. It is impractical to attempt a decontamination without an appropriate Authorization from the Regulator and without having identified a safe, legal disposal route for the waste. A policy of openness with the Regulator is used.

The Regulator must: Agree End Point *(legally, this is partly defined in the Regulations but the Regulator should confirm the interpretation in order to avoid any later disputes).*

Confirm that job is necessary (Justification is required under EU Directives, to be strengthened in UK Legislation later this year).

Publicity must be expected. It is better to Inform the Media that a job is to take place. If any adverse publicity results, it should occur at the planning stage and not when the works are taking place. If Regulators have been consulted and kept fully informed, they will give the same answers as you. The locally elected authorities should also be involved as they have a considerable role in acting as an interface to the public. However, in the UK, such bodies only have a minor role in relation to radioactive materials.

Contractors need to be aware that their work is subject to scrutiny. Such scrutiny has to be technically competent due to the specialist nature of the works.

MOD will not pay for work which is not of sufficient quality. Greater care is taken with the work and greater openness by the works contractor results. All safety and disposal records should be examined on a regular basis.

DERA/DRPS role in this is as the RPA (a legally required post) and technical adviser to the UK MOD for the Project. It is noted that although MOD use commercial firms to carry out the work, MOD is nevertheless responsible for ensuring that this is carried out in a safe and professional manner. Furthermore, MOD continues to own the waste until its authorised disposal. DRPS advise the Project Sponsor on the technical areas relating to this.

This frequently involves DRPS being given an oversight role in the contract regarding the carrying out of the work and the confirmation of the contractor's clearance certificate. As MOD retain overall responsibility, they have the right to halt the job at any time if any safety questions arise. Step in and dispute resolution rights are also retained by MOD.

Addressing these areas early in the project leads to the formation of a motivated team who are aware of their roles and responsibilities. The creation of such a team reduces the chances of poor information flow and poor performance, which therefore increases the probability of successfully dealing with the legacy of past practices.

Radioactive Wastes in a Conventional Military Environment

By

S M CLARK

DERA

Why Luminise

Advantages of Radioactive Luminising

- Permanent
- Low Weight
- Low light intensity

DERA

Luminising Materials and their Properties

Luminising Materials

	Half Life	Toxicity	"Environmental Persistence"
Radium-226	1600 yrs	High	High
Promethium-147	2.6 yrs	Medium	Low
Tritium (Hydrogen-3)	12.26 yrs	Low	Low

DERA

Site Contamination Mechanisms

- Waste Disposal
- Poor control
- Past remediation

DERA

Key Areas

- Contract
- Regulators
- Media/Publicity
- Audit/Checking

DERA

WASTE MANAGEMENT COMPLIANCE IN THE ARMY OF THE CZECH REPUBLIC

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Introduction

The key area in providing environmental safety is the issue of effective management of waste being created during the daily life and training of troops. Law No 125/1987 concerning wastes, which came into existence last year, is the fundamental regulation in the Czech Republic. The law determines the liabilities in wastes disposal and prevention of their origin and it modifies supervision by state authorities and their decision-making process. It fully applies to the military sector with only one specific enactment - records of wastes produced by the Ministry of Defence are processed and kept by this Ministry in cooperation with the Ministry of Environment. [1]

Waste Management Act

This edition of the new Waste Management Act changes the present system of waste management in military properties and training areas. A number of new regulations result both from the membership of the Czech Republic in OECD and from the Basle Convention. Our adaptation to the EU law in the field of waste management has been basically completed. [2-6]

When defining unit commander basic responsibilities it is necessary to respect the elementary goals of the law, mainly:

a) To make an effort to prevent creating the waste and to reduce the current amount of waste being produced,

b) If the waste has already been produced, then it is necessary to provide maximal reduction of hazardous waste proportion,

c) To increase the proportion of exploitable wastes, for example by designating the liability for sorting the waste and offer it constantly for exploitation, etc.,

d) The liability to abide by the provisions of generally valid waste management legal regulations and Administrative Law.

Paper presented at the RTO SAS Symposium on "Approaches to the Implementation of Environment Pollution Prevention Technologies at Military Bases", held in Budapest, Hungary, 5-7 May 1999, and published in RTO MP-39.

Commander's liabilities

Explicit definition of military unit commander's responsibilities is one of the significant prerequisites to ensure fulfilment of requirements arising from the law and waste management optimalization within the ACR. At present the general liabilities determined by legislative amendment are being solved partially by internal normative acts of the Ministry of Defence. [7,8] Abiding the act's provisions under military conditions, the commander's general liabilities may be defined in relation to the waste management in the following way:

1. Commander is responsible for waste management operations in his unit or facility,

2. Within his area of responsibility, the commander assigns an employee, who is directly responsible to him for the implementation of tasks in the area of waste management. This employee keeps the records of waste, and according to service rules, he sends reports on waste production to the Chief Ecologist of the Army. This employee also supervises and represents the organisation at the appropriate meetings,

3. In his work, he abides by the internal normative acts by which the generally valid legal amendment is complemented or expanded with military specifications. He is obligated to follow expert instructions of the Ecological Group at the Ministry of Defence and cooperate with its Territorial Ecologist,

4. He abides by the decisions of state authorities (Ministry of Environment Territorial Department, District Department, Community Department) and cooperates with expert ecological institutions, organisations and civil initiatives,

5. He is obligated to provide waste management in a maximum effective way by first exploiting local possibilities and only secondarily by exploitation of external possibilities,

6. He must provide security for classified information regarding waste management activities.

The Army organisational and operational measures

According to the Act [1] and implementary decrees [2-5] the Army, as a waste originator is obligated to do the following:

A. To accept the elementary goals of the Act mentioned above and support them in practice;

B. To categorise and catalogue the waste in compliance with decree [2], which is fully compatible with the decision of the European Union Commission No 3/94, by which a new European catalogue of wastes has been introduced. Categorisation is understood as an assignment of the category "hazardous" or "other" according to the current waste properties. Cataloguing is an assignment of a name to the particular waste together with a six-digit numerical code. Expert help is provided by an appropriate Territorial Ecologist of the Ministry of Defence;

C. To provide waste disposal. This liability is provided by a commander and his designated employee responsible for the waste management. Maximum effort has to be made at every military unit to recycle each kind of waste first internally and only then externally. Waste which cannot be exploited is to be offered to another legal or natural person (firm) for disposal. The waste is offered to the firms for exploitation either directly at regular monthly intervals or within the framework of

centrally offered possibilities, the commander may use collective depots in selected units, respectively designated collection points at Logistics Headquarters storage facilities [9];

D. To operate military landfills in the military training areas, if they are established. Only wastes specified in the dump operational instructions can be put in the landfill. Emergency instructions, operational instructions and operational records are worked out for the landfills, as well as for Logistics Headquarters and collective depot installations. The army has to provide collection of all municipal waste with classes of hazardous components at the military training areas which are under the responsibility of Military Authorities of the Local Communities with a status of a municipality;

E. To collect specified types of waste in the Logistics Headquarters central installations (collection points at storage facilities), which are specialised according to material groupings. This process is based on regulations issued by the General Staff of the Czech Army. Scraped material has to be transported to the mentioned installations and it becomes waste only here after it is removed from the record [9];

F. To store separated hazardous waste in the collective depots special containers (Dutch system, Ecotainer and Ecocar). Depots are located in chosen army units. Their operation is controlled by a competent unit commander in cooperation with the assigned employee. Waste disposal and all administrative work is provided by a firm chosen in a competition. Additionally this firm is an accredited body for the Army of the Czech Republic;

G. To check hazardous properties of wastes and to handle them according to the actual properties. The list of hazardous properties is introduced in the annex of the Act and it is evaluated according to the limits stated in the decree. [4] The evaluation of hazardous properties can be carried out exclusively by the assigned person, who is kept in the record of the Ministry of Environment or the Ministry of Health of the Czech Republic;

H. To collect the sorted waste in compliance with type and categories. Waste can be stored only at the places designated for that purpose. In the case of hazardous waste, every sort must be provided with the hazardous waste identification sheet [3] and a symbol in the agreement with special regulations [6];

I. To secure the waste against depreciation, theft or leakage into the environment at locations where the waste is stored and sorted, then at hazardous waste collection depots, Czech Army landfills and at the collection points of the Logistics Headquarters central installations. Logistic storage facilities with discarded equipment and ammunition, where disassembling and dismantling take place, are liable to a special regime and supervision;

J. To keep the records. Military waste records are no longer completed by state authorities. To keep the records for every type of waste on a separate form continually at each waste origin, its receipt, transfer to another army element or another firm, etc. The forms are recorded for every collection point and are archived for a minimum of 3 years. An annual report on waste origin is produced by an army element for every calendar year and is delivered by official procedures via the Territorial Ecologist to the Chief Ecologist of the Ministry of Defence by the 15th February of the following year [7,8] A summary report is sent from the Ministry of Defence to the Ministry of Environment by the end of May of the following year;

K. To allow control authorities access to buildings, sites and installations and upon request to produce documentation and provide truthful and complete information related to waste management. The control authorities are as follows: Ministry of the Environment of the Czech Republic, Czech Inspection of the Environment and district authorities;

L. To secure the transfer of waste in compliance with the requirements of the waste management acts to include the Basle agreement. Continuous legal amendment is provided by the European Agreement on International Shipment of Hazardous Items (ADR). [6]

Conclusion

The new legal amendment creates a challenging environment for more efficient waste management. Enhanced technologies for waste collection according to its type and category are implemented into practice of the military sector.

Commanders of military units and installations have to realise new liabilities and duties resulting from the waste management law and prepare organisational, administrative, operational and economic measures. To prevent financial penalties for not meeting the legal requirements it is recommended to involve the Military Units Environmental Commissions and appropriate MoD Territorial Environmental Bodies in the region.

New principles of waste management in the military environment are a subject of the armed forces members professional training and education. The main areas of concern include the following: Commander's obligations regarding waste management law and administrative law, duties of the Military Unit Commander while handling the waste, waste disposal systems, registration both in military units and collection sites at the Logistics Headquarters, etc. [9]

Environmental Management System implementation is the systematic measure of the ACR being taken to ensure environmental safety and permanent harmony with environmental law within the military sector. At the same time the mentioned initiative is a reflection of NATO Environmental Committee pilot projects. [10,11]

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HAAKONSVERN NAVAL BASE, BERGEN-NORWAY
POLLUTION PREVENTION OF PCB-CONTAMINATION IN SEA SEDIMENTS

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ABSTRACT

In this paper the prevention of PCB-contamination in sea sediments at the Haakonsvern Naval Base in Bergen, Norway is discussed.

INTRODUCTION

Norway's largest naval base, Haakonsvern, is situated near the city of Bergen in Western Norway. In 1992, about 30 years after the base was constructed, environmental investigations indicated that the soil at some locations at the base was contaminated with PCB (polychlorinated biphenyls). The following investigations also showed that the sea sediments around the base are contaminated with PCB. In addition to PCB the soil and sediments also are contaminated with PAH (polycyclic aromatic hydrocarbons) and heavy metals, but the main and most severe pollution is caused by PCB. The concentration of PCB in fish and shellfish in the area is so high that the food control authorities have imposed a ban on consumption. The registration of contaminants in the sea is well documented by surveys, between 1992 and 1998 more than 500 sediment samples from around the naval base have been analysed. Also fish and shellfish has been sampled several times from different locations.

After the detailed survey of the distribution of the PCB-contaminated soil and sediments, the Norwegian Defence Construction Service have forwarded a pollution prevention plan containing two main measures:

1. Prevention of further leakage of PCB from contaminated soil on areas at land into the sea and remediation of the most severely polluted soil.
2. Prevention of further spreading of PCB from the contaminated sediments to sea organisms such as fish and shellfish with the aim to remove the ban on consumption of sea organisms after a long time period.

Paper presented at the RTO SAS Symposium on "Approaches to the Implementation of Environment Pollution Prevention Technologies at Military Bases", held in Budapest, Hungary, 5-7 May 1999, and published in RTO MP-39.

MEASURE 1: PREVENTION OF FURTHER LEAKAGE OF PCB INTO THE SEA

The first site at the base, identified as contaminated with PCB, was above the fire fighting training field where waste oil was burned. It is likely that attempts to burn PCB-oil had been made at this site. Later an additional site was found at the small boat quay. At both sites it was decided to remove the PCB-polluted soil. At the base the environmental authorities allow a maximum concentration of 1 mg PCB/kg dry soil.

The most severe PCB-pollution on land was found when drainage pipes and sewage pipes were inspected. Analyses of the mud in the pipes, registered concentrations up to 5 mg PCB/kg dry matter. The PCB found is probably only remnants of larger amounts of PCB, which already has leaked into the sea. A detailed survey of the drainage pipes and sewage pipes at the naval base showed that many of them have their outlet to the sea. The preventive action to avoid further leakage of PCB into the sea was to clean all the drainage pipes and sewage pipes with the aid of a vacuum-cleaning truck. The source of the PCB in the pipes not known, due to the large amount of workshops on the base.
Measure 1 is now almost finished and the actions, which have been taken, should assure that there is no more PCB leakage into the sea.

MEASURE 2: PREVENTION OF SPREADING OF PCB-CONTAMINATED SEDIMENTS

Prevention of spreading of PCB-contaminated sediments at a naval base is quite a difficult task. Heavy vessels and submarine traffic causes sediment particles to go in suspension. At the Haakonsvern Naval Base there is also a diving school where underwater blasting is one of the exercises. This exercise is now mowed outside of the base due to the contamination in the sediments.

Two alternatives were studied for preventing the spreading of PCB-contaminants:
1. Covering the contaminated sediments in situ with a geotextile, and finished off with 40-60 cm clean sand.
2. Removing the contaminated sediments by dredging followed by placement in two depot basins.

It was decided to choose alternative 2 where the sediments were removed from the sea floor. Alternative 1 was not chosen because this implied imposing restrictions on anchoring, blasting etc. In addition the cost of implementing both alternatives was at the same level for shallow waters, but for deeper waters the analyses concluded with that covering the sediments was going to be very difficult and expensive.

The areas, which are going to be dredged, have water depths between 5 m and 65 m. Due to the many technological challenges it was decided to dredge in two phases. Phase 1, where about 10 % of the contaminated sea floor was dredged was performed in 1998. About 25.000 m^2 sea floor was dredged and about 4.000 m^3 contaminated sediments were removed. These were pumped into the nearby depot basins constructed for this purpose (see figure 1). There was no dewatering of dredged material, the depot basins are constructed in such a way that the clean water was channelled back to the sea through the dam filter, the contaminated sediment particles remaining in the depot basins.

The result of the dredging in phase 1 was that the average PCB-concentration in the sediments was reduced by 91 % from 0,813 mg/kg dry matter to 0,076 mg/kg dry matter. The target, to reduce the PCB-concentration with 85 %, was thereby exceeded. The cleanup limit for the contaminated sediments which have to be removed is set to 0,1 mg PCB/kg dry matter. The highest value of PCB registered in the sediments is 6,7 mg PCB/kg dry matter.

Encouraged by the success in phase 1 the even more challenging phase 2 is planned to start in August 1999. In phase 2 about 400.000 m^2 of the sea floor is going to be dredged in areas with water depths ranging down to 65 m. It is estimated that about 80.000 m^3 will be dredged. The sea depots have a total capacity of 100.000 m^3. Phase 2 (dredging and placing the contaminated sediments in the depot basins) is estimated to finish in the beginning of 2001. It has been assumed that the ban on fish and shellfish consumption can be lifted in about 10 years after the operation has been completed. Ten years is the estimated lifetime of the contaminated fish in the area.

Concern has recently been raised if the aim to remove the consumption ban can be reached, as recent studies have shown that the fjord areas around the naval base are more polluted than was originally thought. If these areas are not also cleaned up, the fish population in the area will remain exposed to PCB-polluted sediments. These sediments are polluted by different civil activities. So far no plans have been introduced to clean up the sediments polluted by civil activities.

COST OF THE PREVENTIVE MEASURES

The cost of the preventive actions (Measure 1 and 2) is estimated to reach almost 120 million NOK (about 16 million US$). About 90 % of the costs are related to Measure 2. The conclusion is that in a case like this, it is very important to implement preventive measures, which stop the leakage of the pollutant into the sea as early as possible.

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The Clean-up of Contaminated Military Sites, Consequences for a Pollution Prevention Approach, Requirements from a Viewpoint of Environmental Protection

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1. Background and Terms of Reference

This seminar is held as a follow up of the NATO Study on "Environmental Technologies" which was concluded in September 1996.

Focus of this study was
- to get a better understanding of contamination from military sources,
  to identify existing or evolving technologies and strategies to minimize environmental impacts of military operations and its areas for potential application in the military
- to identify research and development activities which may be required in the future.

The study was focused on the following substances:
- Petroleum, Oil and Lubricants (POLs)
- Munitions, Energetics, and Propellants
- Ozone Depleting Substances (ODS), Fire Suppressants and Refrigerants
- Volatile Organic Compounds (VOCs), Solvents and Surface Cleaners
- Inorganic Surface Coatings
- Organic Surface Coatings
- Shipboard Liquid Waste
- Shipboard Solid Waste
- Pesticides

Paper presented at the RTO SAS Symposium on "Approaches to the Implementation of Environment Pollution Prevention Technologies at Military Bases", held in Budapest, Hungary, 5-7 May 1999, and published in RTO MP-39.

The military and the environment is a fascinating issue, since this is almost the only field in modern societies, where there is a certain prerogative when it comes to environmental protection, to environmental information and to environmental action. Additionally the military loves to have an aura of secrecy around what it does and, there are rumors also around what it does not do. It is encouraging to see that there is a growing concern about the environmental impacts of peacetime military operations. And the whole setting of this study is fascinating, since it produces a déja vue feeling at least for people who look at it from a view point of environmental administrations.

2. The Findings of the NATO CCMS Pilot Study on the Environmental Aspects of Reusing Former Military Lands

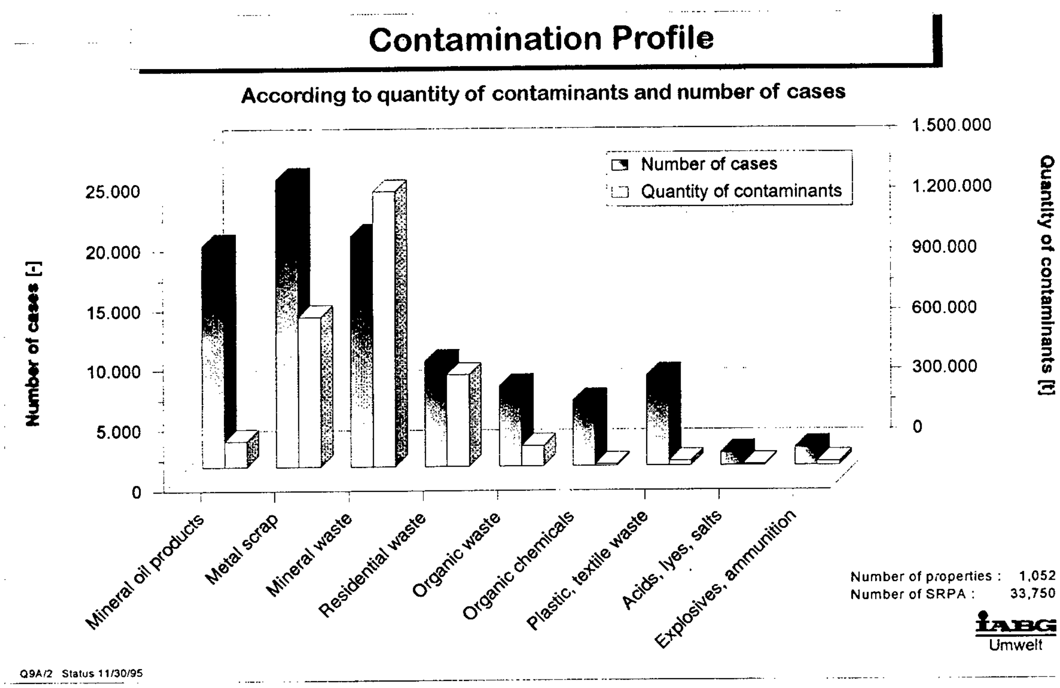
Parallel a NATO CCMS Pilot Study on Environmental Aspects of Reusing Former Military Lands was executed and co-chaired by the USA and Germany. Phase I of this Study was also terminated at the end of 1996. Its terms of reference for Phase I called for the creation and enhancement of national capacity and capability to effectively address environmental aspects of conversion in particular:

- organizational planning approaches,
- personnel requirements,
- methodologies and processes,
- planning, programming and budgeting,
- remediation strategies and technologies,
- cost-benefit analysis,
- execution and execution oversight.

Much effort was spent on categorizing the most important pollutants found in cleaning up former military site, to describe the impact of these pollutants on military lands and to produce a link to existing state-of-the-art remediation technologies. Not everything related to this CCMS pilot study is of relevance for the subject of pollution prevention at military bases, some of its findings definitely are.

Great effort was put in assessing pollution found at military sites and putting this information together. Table 1 gives a summary of typical contaminants found at former Russian military sites in Germany and the amount of cases.

Table 1 Suspected Contamination Areas by Type and Quantity of Contamination and by Number of Cases (Russian sites in Germany)



The groups listed here do not completely correspond with the substances subject of the study on pollution prevention. This has obvious reasons. The "Reuse Study" mainly looked at soil and groundwater pollution at former military sites. Volatile compounds where not of special interest here. Shipboard wastes were not covered by the „Reuse Study“.

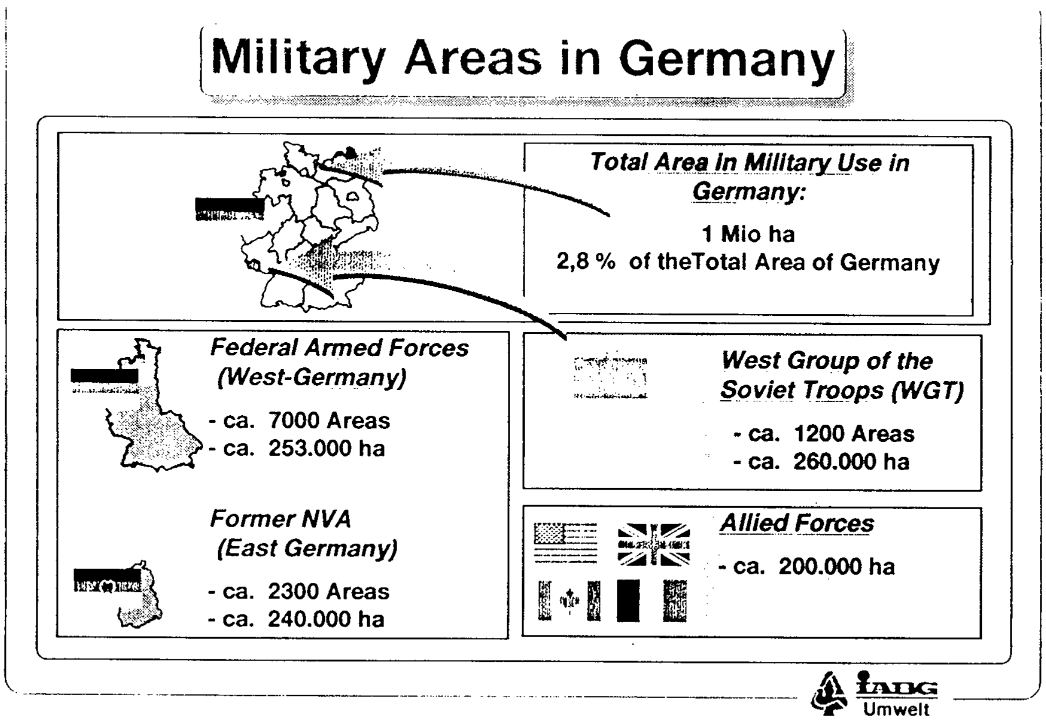
Regarding the other substances it is quite obvious that these also contribute to environmental problems at military sites, though to a quite different extent. Leaving aside cases of improper waste management the study quite clearly shows that particularly POLs and organic chemicals are responsible for by far most of the cases of contamination of land. Since these substances are not used in "open systems" it is also obvious, that losses are the result of poor design and maintenance of the systems and of careless or negligent usage of these substances.

Germany has quite a bit of experience in assessing environmental damage at military sites. Up to its reunification it had the highest density of military in the World, altogether about 2 million man under arms, occupying a territory of over 2 millions hectares.

It was not only German military from the eastern and from the western part of Germany, but also Russian military, US, British, French, Canadian, Belgium and Dutch military stationed for a long period in Germany.

Figure 1 gives an overview over the amount of land used for the military and the number of troops stationed in Germany during the "cold war" time. The numbers there will be reduced to half once the process of reducing the military and returning sites for civilian use will be finalized.

Fig. 1 Military Use of Land During the "Cold War" in Germany



Now that many of military sites and installations are given up and returned to the German government, it was a challenge to compare the kinds of environmental damage that could be found at facilities managed by different nations. The outcome of this comparison was stunning.

The substances causing damage and the kinds of damage were the same whichever was the country whose army was tenant at the facility. If at all there were gradual differences in the extent to which the military was negligent with hazardous substances, the substances as such and the places of contamination are in principle the same, whether Russian or American, whether German or French.

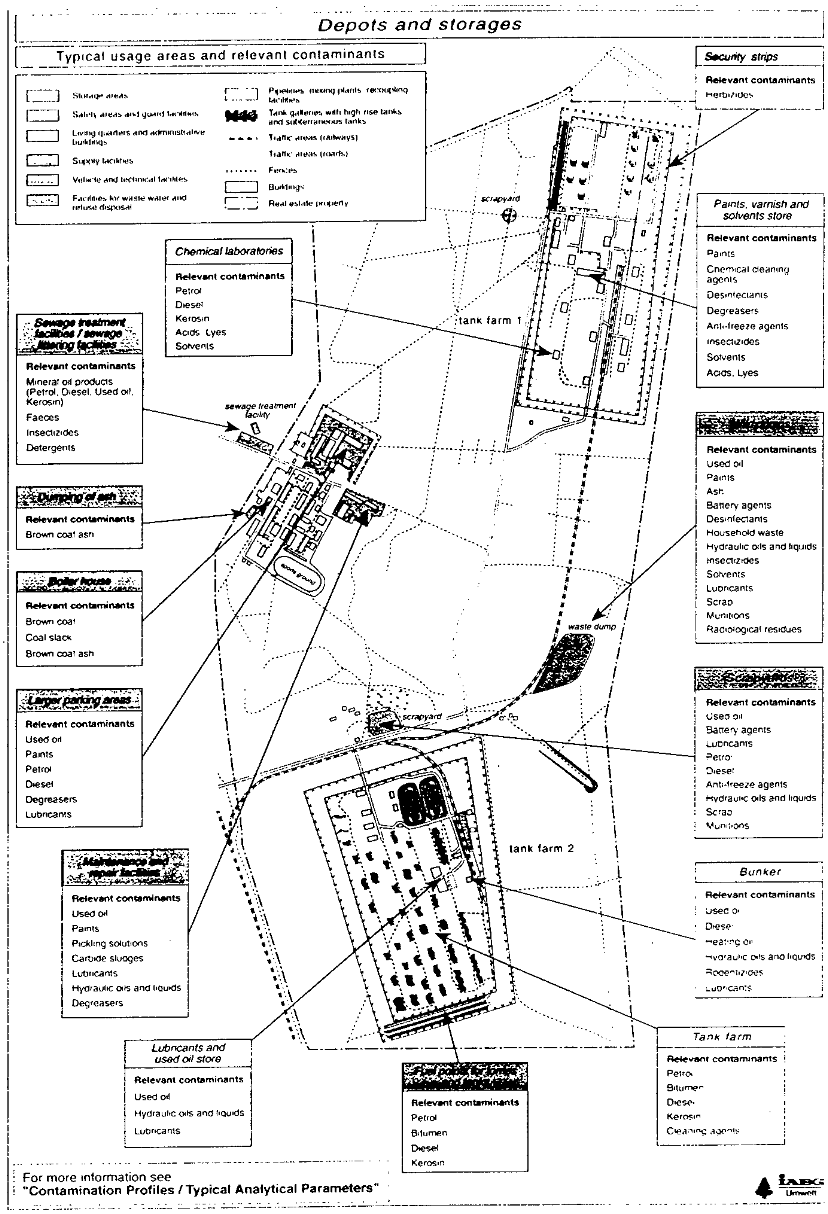


Fig. 2 Example of a „Contamination Profile“

3. Cross Referencing the Studies

It is very interesting to see that although there was not very much cross-referencing between these two studies the study on Environmental Technologies was focusing on Pollutants which have been identified as being typical for environmental impacts on military lands.

One may think that this is quite natural since after all there were expert groups dealing with the issues and perhaps it is quite natural indeed, after all it is encouraging to see that the work of two independently operating working group comes to similar conclusions when cross referenced. The study on „Environmental Technologies“ gives an excellent coverage of the relevant pollutants in military use. Pinpointing the problem however, does not solve it. Although there cannot be disagreement on the selection of pollutants for the long term scientific study there may be different ways to look at the lessons to be learned.

One lesson is obvious and backed by both studies. The military still has quite a substantial pollution potential, even if everything possible is done to keep hazardous material as much in closed circuits as possible. Very often the state of the art - as practiced in the „civil“ World apparently has not been accepted for military use.

It can only be hoped that a powerful organization like NATO which through its sub organizations has a lot of environmental studies ongoing will after 50 years of existence create policy mechanisms to make best use of the findings of such studies. Until now it is apparently exclusively up to the individual member state to draw its own and specific conclusions. The outcome of the studies will therefore not directly be used within the NATO framework. This is very unfortunate since the systems should be interchangeable and since the market for military goods is rather limited and the most powerful suppliers may be the least interested to draw the necessary conclusions. Some mechanism to avoid this from happening should be envisaged.

Another point is obvious: There are different groups of polluting substances used by the military which can be categorized in different ways. The grouping to organize this work was use oriented following the chemical specifics. If you look on the substances and how to tackle them in a more policy oriented way you may come to the different groupings:

There are for example substances in use by the military and the general public likewise (in the same manner). This is the case for most of the fuels and lubricants (POLs) (for aircraft, vessel and motor vehicles). This group of substances also comprises the VOCs, the Surface Coatings whether organic or inorganic, the Pesticides and to a large extent also the shipboard waste.

The Rest of the groups is "military only". In this group you will find the ODSs, not as such but in the kind of way it is used by the military and the Munitions, Energetics, and Propellants.

What is the advantage of such a categorization? It opens a door to comparing what is going on in the rest of the World, i.e. the civil World. Following such an approach will make it more natural for the military to accept and put into military practice what is developed for the civil World and working perfectly well there.

The current argument against taking this approach is generally cost and secondly specification. Both of these arguments have to be looked at very carefully before they are taken aboard.

The cost argument is an argument that cannot be accepted. If cost is not an argument for the civil sector, then it cannot be an argument for the military to resist certain developments or demands. It has to be born in mind that the military is part of the government administration of the countries and in this function it has to provide leadership also in environmental protection.

The often made request for transition periods is quite acceptable. Transition periods are always needed when stocks have to be replaced or when certain equipment has to be put out of service.

So in principle there should be agreement, that what is possible for the civilian side of society should also be feasible for the military side. In fact it should be even simpler for the military to follow what is environmentally sound and necessary. The military has exceptional market power. Often it is the only or the most important business partner for certain industries. Developments are generally made on the basis of tenders, not under free market conditions. The influence of the one who pays, generally the Ministries of Defense should be quite substantial. This demand power ideally should be used to make things that are environmentally necessary happen in practice.

4. Conclusions

Looking at the part of the conclusions of the study there are some indications on how to proceed with this study in the future that are missing. Integrated pollution prevention for the military means that the standards used by the military should, wherever possible, not differ from standards applicable to the civil parts of society. This seems to be the most important frame condition to look at. Although this is accepted in theory, there are doubts how this is done in practice.

Unless there are particular and very strong reasons for exceptions, the same environmental standards should apply for peacetime military activities as for comparable civil activities.

The first question that should be asked is: Is it necessary for the military to use special material specifications. This question does not seem to be asked too frequently.

Military production will of course follow military specifications. It is therefore essential that environmental concerns will be considered at a very early stage when the specifications are made and when the first proposals on how to follow the specifications are available.

A code of conduct on behalf of the military would help to stop unproductive developments and to avoid the production of systems which are in conflict with environmental concerns.

After the use of Agent Orange there are also concerns about the specifications of certain chemicals and weapons used in warfare. The latest of these concerns is the actual discussion on the use of depleted uranium munitions in the Kosovo Conflict and the impact these munitions had in the Gulf War. Of course, weapons are developed to harm, but it is clear that they should only do harm on the battlefield and insofar as possible avoid incidental damage.

For military equipment, supply and other activities a "cradle to grave" approach is needed based on an environmental impact assessment. Such an assessment shall consider all the foreseeable impacts of certain material and equipment throughout its life cycle, also taking its out-of-use fate (disposal) into consideration.
Bring military installations to an up-to-date status also environmentally in
- keeping emission standards
- upgrading fuel delivery, distribution and storage facilities and equipment.

Use bad experiences made with outdated systems for new systems to avoid making the same mistakes again. This is almost common sense.

CONTAMINATION FROM MARINE PAINTS – A NORWEGIAN PERSPECTIVE

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1. Introduction

Marine paints have been used for over 100 years to protect ships from weathering and biological and chemical degradation (1). In order to obtain the right marine paint quality various substances increasing the anticorrosive, antifouling, mechanical flexibility, weatherability, chemical and cold resistance properties were added. Many of the additives that have been used and are still being used today are toxic compounds for man and other species. Spills of paint residues and leakage from painted objects will eventually be deposited in the sea sediments and will therefore potentially pose a threat to the marine environment. Biocides and various other additives used in antifouling paints seem to give the most serious problems ranked according to impact on marine life.

Antifouling paints are designed to give a thin boundary layer in the water around the hull were the concentration of antifouling agent is high enough to kill algae and other organisms that would otherwise remain attached to the hull. With the water acting as a sink, there will therefore need to be a continuous release of toxic compounds from the hull. These compounds have high affinity to particles in the water column and will therefore quickly settle on the seabed.· Contaminated sediment will subsequently be a source for resuspension or dissolution in the water column or a direct source for bottom feeders.

In Norway a majority of harbours and areas adjacent to main ship repair yards have highly contaminated sediments (2,3). This has resulted in elevated levels of toxic compounds in fish and shellfish living in these waters and guidance on their consumption has been issued by the Norwegian Food Control Authority (4). In many cases the prime concern is the elevated levels of PCBs (Poly Clorinated Biphenyls). At Haakonsvern Naval Base the Norwegian Defence Construction Service has commenced actions to remove contaminated sediment (5).

The sources of some of these contaminants, such as TBT (tributyl tin) have been firmly established to be antifoulants due to its unique application. However other contaminant sources remain elusive, such as PCBs, in part due to the mixing of multiple source signals over a period of several decades, in part due to the limited accessibility of the composition of historical and contemporary marine paints. An investigation into the link between contaminant concentration in sediments at Haakonsvern Naval Base and the use of marine paints is presented here. Estimation of the amount of paint residues washed into the harbour basin since the opening of the base in 1963 is lacking at present. However, there seems to be a correlation between especially copper and other heavy metals found in the sediments and compounds used in marine paints. It is shown that sufficient quantities of PCBs were present as part of chlorinated rubber additives in marine paints in the 60's and early 70's and can explain the current sediment concentration of PCB. Although the Norwegian use of PCB in marine paints was stopped in 1973, paint residues taken from a ship in 1996 showed significant levels of PCBs. This highlights the need to prepare adequate collection systems where marine paints are removed.

2. Biocides and anticorrosive additives in marine paint

The soluble matrix used in conventional antifouling paints released the biocide relatively quickly and the useful life time of the paint was approximately one year. In this type of paint the biocide was released as the binder dissolved. It was therefore necessary to repaint the hull each year, causing a high consumption of antifouling paints. Later insoluble-matrix-based antifouling paints were introduced and the life time was increased to two years, reducing the amount of copper and other toxic compounds released into the

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environment. In order to further increase the life time, self-polishing copolymer paints were developed. With this matrix the life time increased to three years for organotin-free paints and five years for organotin containing paints which today have a market share of over 80 %. The increased life time for organotin paints is caused by the covalent bonding of the organotin compounds to the matrix giving a constant release rate of organotin. Table 1 gives an overview over the history of the development of antifoulants.

	Generic type	Binder	Biocides
Before 1950	Conventional	Rosin	Cu_2O
1950 - 1960	Long life	Rosin/vinyl	Cu_2O
Late 60's	Long life	Rosin/vinyl	Cu_2O/TBTO
Mid 70's	Self-polishing	TBT-copolymer Low-built	Cu_2O/TBTO
Early 80's	Self-polishing	TBT-copolymer High-built	Cu_2O/TBTO
Mid 80's	Self-polishing	TBT-copolymer Low tin	Cu_2O/TBTO
Late 80's	Ablative	Copolymer	Cu_2O/TBTO, other organic biocides
Early 90's	Self-polishing	Copolymer	Cu_2O/organic biocides

Table 1 Overview of the development of antifoulants

Various heavy metals have mainly been added to give the marine paint antifouling and anticorrosive properties. Marine paints have also been added pigments containing heavy metal. Copper has been the traditional compound used as a biocide in antifouling paints. The concentration of copper in antifouling paints is reported to be 10-30 %, but as much as 50 % has been used (1). Normally Cu_2O is used as the biocide, but also CuSCN and copper metal are in use.

Mercury was added to antifouling paints as a biocide in the past. Both inorganic mercury and organomercury were used (1). The concentration of mercury in paints is somewhat uncertain but about 5 % could have been added to the paint (6). Arsenic was also used in the past as a biocide in antifouling paints (1).

Lead has been added to antifouling paints as a stabilizer, a pigment and a biocide (1). Both inorganic and organolead compounds are used in marine paints. The concentration of lead in antifouling paints is typically 1-5 %. Lead was previously widely used in anticorrosive paints, but has now to a great extent been replaced by zinc and aluminium. Cadmium and chromium were also in the past added to give the paint anticorrosive properties and colour.

In the late 60's organotin compounds replaced the traditional copper-containing antifouling paints, because of its excellent antifouling properties. Tributyl tin (TBT) is the most used organotin compound but also triphenyl tin (TPT) is used. The amount of organotin compounds in paints is normally about 10-15 % (1). The use of organotin compounds was banned in most of the world in the 80's for vessels of length less than 25 meters and were replaced by other organic biocides. However, organotin compounds are still widely used on large ocean-going vessels.

Other organic biocides were used as a replacement for organotin. Several pesticides are used as a biocide in antifoulants. Examples of pesticides in use are Diuron and Zineb. DDT was also used as a biocide in antifoulants in the past (7) and it is possible that other persistent chlorinated pesticides have been used in antifoulants.

Prior to World War II and untill the early 90's chlorinated rubber was used as a binder in marine paint. To improve the quality of chlorinated rubber-based paints, PCBs were added as a plasticizer giving the paint good adhesive properties. PCBs also gave the paint excellent resistance against moisture, chemicals, corrosion, and flames. PCBs were added to chlorinated rubber in a concentration of about 10 % resulting in a total concentration of PCB in paints of about 2 %. PCB-containing paints were used as protective and

decorative coatings for wood, metal, brick, stone, concrete and fabric surfaces (8). In 1973 OECD recommended restrictions on the use of PCBs (9), and PCBs in paints were gradually replaced by chlorinated paraffin. Norway banned all new use of PCB-containing products in 1980, but some products are still in use.

Table 2 shows the Norwegian paint producers use of PCBs (10). The amount of exported PCB-containing paints from these manufacturers is unknown. From Norwegian authorities it is estimated that about 44 tons of PCB-containing paints were used in Norway (11). Technical paint experts have estimated that about 10 - 15 % of this paint still can be found on ships today, meaning that about 7000 kg PCB are on ships today. If all of this is drained to the marine environment it would contaminate 47.000.000 m^3 of sediments with a PCB- level of 0.1 mg/kg.

Year	Tons
< 1969	35 - 40
1969	10
1970	12
1971	11
1972	2 - 3
1973	0

Table 2 Use of PCB by Norwegian paint manufacturers

3. Paint removal and waste handling

There are two ways of removing old paint and fouling from the hull, sand blasting or the use of high pressure water washing. Waste from sand blasting is generally collected and handled in proper ways today, but in the past the greater part of this waste was drained to the harbour basin. Waste from high pressure water cleaning of the hull is more difficult to collect than waste from sand blasting and even today this waste is mainly drained to the harbour basin. Ship repair yards in Norway have few or no collection systems for waste from high pressure water cleaning of the hull, implying that contamination of harbour basins with paint residues, including antifoulants, continues.

During the spray painting of a vessel a significant fraction (up to 30 %) is released to the environment (12) and the greater part of it is drained to the harbour basin. The application of marine paints is therefore a considerable source of sediment and seawater contamination in harbour basins.

4. Contamination of sediments and sea water with toxic compounds in marine paints

Several investigations of the contamination in marine sediments along the Norwegian coastline shows high concentration of some heavy metals, organotin compounds, PCB and PAH in harbour basins, outside ship repair yards and marine paint factories. This is mainly explained by leakage of biocides from antifouling paints during port call, drainage of marine paints from ship repair yards and paint disposal from paint factories. There is also leakage of oil products from vessels visiting harbours which will give high levels of hydrocarbons in harbour sediments.

The Norwegian State Pollution Control Authority has given priority to cleaning up the sediments in about 20 harbours. These harbours have heavy ship traffic, and often one or several ship repair yards are present or have been present in the past. The ranking of the harbours is based on analyses of a few sediment samples and it is therefore likely that there will be more than these 20 harbours where clean-up efforts will be deemed necessary as further investigations are carried out.

At Haakonsvern, the main naval base in Norway, clean-up activities have been initiated (5). This pilot project demonstrates that it is very costly to clean-up marine sediments and that there are several technical difficulties in attaining the stated objectives. Both the depth and bottom contours make it difficult to meet the requirements from the authorities regarding rest concentrations of toxic compounds in sediments.

The importance of marine paints as a source of PCB contamination of sediments in Norway has recently been addressed by various institutions (13,14,15). Samples of antifouling paints taken in 1996 from a wooden Navy vessel were analysed for content of PCBs at Forsvarets forskningsinstitutt (Norwegian Defence Research Establishment). The maximum concentration of PCB in the paint samples was a surprisingly high 270 mg/kg dry sample and the PCB mixture was preliminarily determined to be Aroclor 1248/1254. It was reported that the vessel was sand blasted in 1985 and repainted several times between 1985 and 1996 (16). Due to findings in 1996 all marine paints used in the Norwegian Navy were analysed for content of PCBs. The results from this investigation showed no signs of PCBs in paints used today.

There is a good correlation between contamination in sediments and ship activities at Haakonsvern. High levels of PCB, TBT and inorganic contaminants are found outside of ship repair yards and around quay structures. Table 3 shows the mean concentration of pollutants in sediments and in seawater (17,18). Based on the fact that these contaminants were widely used in antifouling paints, it is obvious that drainage of antifoulants from ship repair yards and direct release from the hull during port calls are responsible for a considerable part of the contamination found in the sediments. Results from a risk assessment (6) shows that it is necessary to reduce the level of PCB in sediments to about 0.1 mg/kg if consumption restrictions on fish and shellfish is to be repealed.

	Sediments, mg/kg	*Seawater, µg/l*
Hg	*3.8*	*na*[1]
Cu	*510*	*0,8*
Pb	*270*	*0,06*
Zn	*290*	*3,6*
PAH	*5.3*	*na*[1]
Σ 7-PCB	*0.55*	*0,0002*[2]

Table 3 Average sample concentrations of contaminants in sediments and seawater at the Haakonsvern naval base.

[1] *Not analysed*
[2] *Uncertain measurements*

With the assumption that the concentration of PCB in marine paints were about 2 % it is easy to understand that even spills from a minor fraction of the marine paints used will cause a substantial contamination of the sediments. If 1000 litres of PCB-containing marine paints are drained to the harbour basin about 200.000 m^3 of sediments will be contaminated to a level of 0.1 mg PCB/kg. Assuming that the PCB contamination is distributed to a depth of 15 cm, this would lead to a contaminated area of 1.300.000 m^2. The mean concentration of PCB in sediment samples at Haakonsvern is about 0.5 mg/kg[1]. The contaminated area at Haakonsvern is estimated to be about 660.000 m^2. If the mean contaminated depth is set to 15 cm, only about 2500 litres of marine paints would be required to give this contamination level. On average about 2000 litres of PCB-containing paints were used on a new ship (11). If we bear in mind that a lot of the paint can be lost during painting and that some is lost during cleaning of the hull, it is likely that marine paints are responsible for most of the PCB contamination at Haakonsvern Naval Base. The total amount of marine paints used each year and the ship traffic is high at Haakonsvern. In addition there is evidence that the PCB mixture found in the sediments are the same as used in marine paints.

Improved estimates will be attempted when a record of the paint used and their various compositions can be obtained. It is hoped that such estimates can aid in evaluating the amount of PCB removed from the sediments in the area either by uptake in biota or by dissolution and particle transport in the water phase.

As mentioned above, the concentration of PCB in paint residue from the hull can still be high today. It is therefore still a risk that PCB is being supplied to the marine environment and this should be considered when clean-up operations are planned. If paint on vessels today can contain up to 270 mg PCB/kg paint, it

[1] More recent estimates which are based on a total of 312 samples give the concentration of *Σ 7-PCB* at 0.22 mg/kg.

is possible that substantial sediment areas can be contaminated with PCB after the area is cleaned-up. It is therefore necessary to collect as much as possible of the paint residue coming from sand blasting or other cleaning methods. This waste has to be specially treated according to regulations from the authorities. In Norway there are plans to introduce new legislation requiring analysis of all paint waste for content of PCBs. Paint waste with a PCB concentration greater than 50 mg/kg has to be treated as toxic waste (19).

The concentration of PCBs and heavy metals in seawater around Haakonsvern Naval Base is low although the concentration of these compounds is high in the sediments. As seen in table 3, the concentration factor between sediments and seawater for PCBs and copper is about 10^6, but for lead and zink it is an order of magnitude higher and lower respectively. This indicates that both PCB and heavy metals are relatively immobile and only a slow rate of resuspension or dissolution into the water column or biological uptake in the marine food web takes place.

5. Effect on marine life and consumption restrictions

At Haakonsvern Naval Base fish and shellfish have elevated levels of PCB and mercury. PCBs are very stable in the environment and organisms have a low ability to degrade them, the net effect being bio-accumulation. High levels of mercury are found in fish and shellfish because inorganic mercury is converted to organomercury compounds in the environment and organomercury compounds tend to bio-accumulate. It is also reported (1) that organomercury compounds have been used as a biocide in antifouling paints. Analysis done by Forsvarets forskningsinstitutt shows that about 70 % of the total amount of mercury in mussels is organomercury compounds at Haakonsvern Naval Base.

Other heavy metals, except tin, commonly found in harbour sediments have not been seen to give serious impacts on marine organisms. This may be caused by a regulated uptake and secretion of these metals preventing bio-accumulation.

Release of organotin compounds to the environment has caused imposex in some species of mussels and snails. Imposex in snails has been observed along most of the Norwegian coastline and in some places these snails have disappeared altogether.

6. Conclusion

It is clear that toxic compounds used previously and today in marine paints are responsible for some of the present marine pollution problems in coastal waters. Antifouling paints are the source of most of the contamination of organotin compounds in harbour basins. Large amounts of copper and to some extent lead and mercury found in the sediments originate from these paints as well. There is also evidence that a part of the PCB contamination in harbour sediments has come from marine paints and will continue to do so due to the small, but not insignificant, amounts of PCB that are still incorporated in the coating of older ships. Paint samples removed from a Norwegian naval vessel in 1996 contained up to 270 mg PCB/kg paint residue on a dry weight basis.

In order to establish the importance of marine paints as a contaminant source relative to other sources, more detailed information is required on composition and amounts of applied paints as well as the procedures for paint removal. At Haakonsvern Naval Base, being a major Navy service base and having ship traffic predominantly of naval vessels, it is hoped that sufficient information can be pieced together on past and present practices to give a complete source term for sediment contamination.

Prevention of further contamination of the marine environment in harbours requires collection of as much as possible of the paint residues from sand blasting, high pressure water cleaning and paint scraping during ship repairs. Removal of contaminated sediment is probably more costly and not near as effective as preventive measures at the source. Even if all the waste is collected at ship repair yards, toxic compounds in antifouling paints will be released continuously from the hull and contaminate harbour sediments. It is therefore necessary to develop antifouling paints containing toxic compounds, which have specific effects on target organisms and are easily degraded in the environment.

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THE UK MOD APPROACH TO THE REDUCTION OF VOC'S AT SERVICE BASES

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ABSTRACT

Environmental legislation has forced the Royal Air Force, Army and Royal Navy to perform a critical and comprehensive review of both the processes they undertake and the types of materials they use. The paints and coatings world, in particular, faces many challenges and the UK MOD as a significant user of paints and paint removers has to address the problems associated with meeting environmental pressures whilst retaining existing performance criteria.

This paper will outline the legislation contained within the Environmental Protection Act (EPA) which has been introduced to control the atmospheric discharge of volatile organic compounds (VOCs) and will highlight the consequent implications to the UK MOD. The alternative technical solutions to ensure compliance with the legal requirements including 'Compliant Coatings' will be discussed.

Although the UK MOD faces many challenges within the painting and paint removal field, this paper will concentrate on the refinishing of military vehicles and aircraft and associated processes. These are priority areas, as this process involves a significant consumption of paint materials and, therefore, high volumes of VOC. Work undertaken to introduce compliant coatings as alternatives to traditional solvent based products is detailed and the programme highlights the effective co-operation between the Defence Evaluation & Research Agency (DERA), Army and Royal Air Force Departments and the Directorate of Standardisation. The approach by these departments to reduce the consumption of VOCs from supplementary processes to painting are also outlined. In addition, a brief review of the approach adopted by the Royal Navy will be discussed.

As part of the process the various phases of the project will be discussed. This covers the definition of MOD requirements, which can be unique to the Defence arena. It will review laboratory based performance testing, user trials of the materials and the development of the materials specification concluding with the production of Standards for the materials.

INTRODUCTION

All industrial sectors are being forced to review the potential impact of their business on the environment. In addition to specific legislation, enhanced public awareness is driving companies and government departments to review the various processes they undertake and the UK MOD, although an extremely complex organisation with a

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huge range of tasks and responsibilities, is not immune from embracing the changes required of Industry in general.

One area in which environmental legislation has had a major impact is in the drive to reduce the levels of organic solvents contained in paints and paint removers. This is a major issue for the UK MOD as both the procurement process and the in-service operation of defence equipment will involve painting and re-painting processes at prime contractors and at service bases in various global locations.

To address the environmental challenge, the three services of the MOD have initiated programmes, supported by the Defence Evaluation & Research Agency (DERA), to introduce materials that comply with UK legislation without any reduction in performance. This work has included the standardization activity necessary in order to procure materials, under competitive tender conditions, for service use.

LEGISLATIVE BACKGROUND

The historical development of paints has seen compositional modifications in response to an awareness of environmental and health and safety issues - reductions in the use of lead is an example. During the 1990s, the pressure has increased and legislation is becoming more restrictive. In particular, the introduction of the Environmental Protection Act 1990 (EPA) has had considerable ramifications within the paint industry. The EPA is a wide ranging act and a major part of the document covers the discharge of harmful substances to air, water and land. It includes the atmospheric discharge of volatile organic compounds (VOCs). VOCs are, in general terms, organic solvents with boiling points below 110°C and it has been established that these contribute to the formation of low level ozone pollution, which has health implications to the general population. VOCs also pose Health & Safety hazards to operators using these materials.

As a major part of the EPA is aimed at reducing the discharge ofVOCs, it places significant pressures on the use of traditional paint materials as these formulations generally contain significant quantities of solvents. Solvents provide the carrier medium for the film forming binder/pigment composition and allow the paint to transfer to the selected substrate, by the selected application method, before evaporating during the drying stage.

As painting and related processes are used in a wide range of industrial finishing applications, a set of Process Guidance (PG) notes have been issued by the Department of the Environment to assist with the implementation of the EPA. The PGs cover activities such as 'Coating and Recoating of Aircraft and Aircraft Components' (PG 6/40), 'Paint Application in Vehicle Manufacturing' (PG 6/20) and non-specific painting processes are covered in the general 'Coating of Metal and Plastic' (PG 6/23). The PG documents also contain guidance on the use of materials at the surface pre-treatment and paint removal stages.

The criterion for regulation enforcement is the volume of solvent based cleaners, paint and paint removers used during the process and if the levels are below certain limits that particular installation would be excluded from the requirements of the relevant PG. This emphasises the need to record the quantities of solvent based (VOC) products used, as it is a common misconception that all painting processes need to be modified to conform to forthcoming regulations.

If the audited records confirm that the quantities of paint used exceed the limits within the PG, the user needs to consider two options to reduce the VOC discharge to the atmosphere. The VOC emissions can either be reduced through the installation of an arrestment plant that captures the pollutants or, alternatively, the user can specify the use of 'compliant coatings'. Compliant coatings are defined as products which contain less than the maximum permissible VOC level for that class of product listed in the relevant PG. With a few specific exceptions, the compliant level has a significantly reduced VOC content.

ALTERNATIVE SOLUTIONS

Although end of pipe abatement is a valid alternative for reducing VOC discharge, the plant required is very expensive and is, in many applications, an impractical alternative for MOD units. Arrestment plants rely on absorption, condensation or incineration processes but absorption and condensation techniques are preferred as they offer recovery of the solvent. This solution may be desirable in dedicated paint shops, particularly where production painting rates are very high, in which the investment would be returned and some industrial sites have chosen this solution e.g. automotive finishing plants.

MOD users have decided to pursue the compliant coatings route – as recommended in the PGs. These do not involve the investment of expensive arrestment plant although this new generation of materials may prove to have a more expensive unit cost than the solvent based products in the short term. Compliant coatings can, however, be considered a greener technology, which reduce the VOC content at source. It is important to realise, however, that the PG documents, in general, impose limits on coatings, which are increasingly restrictive with the 1998 figures having limits, which are lower than the 1996 targets.

Limits are expressed as grams per litre (g/l) of VOC content within the paint and typical limits are:

	1998 limits (PG6/23 January 1995)	Typical current paint formulation
General Primer	250g/l	450g/l
Top Coat	420g/l	560g/l

The precise definition of a compliant coating is contained within the relevant PG of interest. In general, it means that the paint product has a reduced solvent content, although it is recognised that in certain circumstances the adoption of a solvent reduced alternative is not possible in the immediate short term and some coatings may prove to be 'compliant' with existing product technology. To reduce the solvent content various alternatives are available to the paint manufacturer but two principle materials are being offered:

a. High Solids Paints - Solvent levels are reduced by increasing the solid content (typically 60-80% solids are used). To retain a product with acceptable rheological properties further formulation changes may be required which can affect other properties of the material;

b. Water Based Paints - These essentially use water instead of an organic solvent as the carrying medium although other formulation changes are required to cope with such a significant change in the chemistry of the paint system. Small quantities of solvent still remain within most formulations but these materials could be classed as a greener alternative than high solids products. Examples of this product include decorative emulsions common to many domestic situations.

As direct replacements for solvent-based products, paint manufacturers have developed products which are either high solids are water based. In fact the appropriate route to follow has caused considerable debate in the paint industry.

Other types of paint technology which can be used to overcome solvent use are powder coatings which are paint formulations in powder form which are cured thermally - these products have no solvent content at all. Radiation cured coatings are also an alternative in which the paints (in wet form) are cured using radiation such as UV or even electron beam - this method of curing requires less energy than thermally cured materials. Although radiation cured coatings have not been used by the MOD, powder coating materials are used for finishing certain components where the item is suitable for stoving at high temperatures.

The remainder of this section covers the technical assessment and introduction of compliant coatings as alternatives to the solvent based products used in Defence applications. Different PG documents, and hence different definitions of compliant coatings, cover the various MOD Departments and the areas are, therefore, covered separately.

PAINTS FOR LAND VEHICLES

Platforms in this category include front line (tanks, armoured vehicles etc) and support vehicles. Both the Army and the RAF have an interest in such equipment and the DERA has supported the Army Technical Support Authority (ATSA), the branch responsible for maintenance painting at Army Base Workshops, and the RAF Surface Finishing Authority (SM35f(RAF)) with the introduction of compliant materials.

The paint scheme with the highest volume use in this area is the Nato Green Infra Red Reflecting finish applied to most vehicles and support equipment and this is specified by the Defence Standard 80-41 [1]. This specification details a paint scheme consisting of a primer, undercoat and two finish coats, i.e. a four-coat system. It is an essentially performance based specification listing the requirements of the scheme - covering a range of properties. In addition to corrosion resistance and other standard paint film properties, a critical requirement of this material is the camouflage attributes that need to be retained in any alternative product. It is also critical that the material is easily applied by brush as Army units undertake touch-up operations under non-workshop conditions.

The laboratory work undertaken has involved the testing of compliant products (mainly water based to achieve the 250g/l primer limit within the PG) offered by paint manufacturers against a draft Defence Standard containing the same tests as 80-41. The performance assessment covers a range of physical, mechanical, corrosion and durability tests of the coating - examples include the scratch test, salt spray test and fuel resistance test. In addition, the suitability of the products for maintenance

painting was evaluated. A maintenance situation, unlike original equipment painting, often involves application to surfaces that are less than perfectly clean. Many of the water-based products were less than satisfactory in this role. Overall, results to date have not yielded suitable direct alternatives to the traditional materials.

More recently, products used as car refinishing materials have been assessed with satisfactory performance results. The use of such commercial products is a logical step to follow but to ensure that the MOD needs would not be compromised, laboratory work has been undertaken together with trials to assess the in-service aspects of the materials.

A change in MOD policy and the availability of improved finishing facilities has also opened the route for the greater use of two pack materials for land side vehicles and consequently the Army Technical Support Authority have initiated work to introduce high solids polyurethane materials into service. As a result of this work, a set of new performance standards have been developed and issued [2].

Following extensive laboratory work and user trials, materials were identified which met service requirements. This phase of work involved considerable dialogue with paint manufacturers to refine their product formulations to meet the required performance.

To ensure consistency of supply and enable competitive tendering, four Interim Defence Standard have been developed to cover the procurement of these materials with the results from the practical work used to provide performance limits on the materials. These have recently been published and can be used as replacements for older Defence Standards that allowed high VOC products. The new standards are detailed below:

Defence Standard	Product Description	Description of Use	Standard replaced where a compliant coating is needed *
INT DS 80-206/1	Paint, Priming, Zinc Phosphate, Two-Pack Epoxy, Non-Aircraft Use, Low VOC	Primer for ferrous based vehicles	Defence Standard 80-114 Defence Standard 80-126
INT DS 80-207/1	Paint, Priming, Zinc Chromate, Two-Pack Epoxy, Non-Aircraft Use, Low VOC	Primer for aluminium and aluminium alloy based vehicles	Defence Standard 80-114 Defence Standard 80-5
INT DS 80-208/1	Paint, Finishing, Polyurethane, Multi-Pack, Matt, IRR, Non-Aircraft Use, Low VOC	Matt finish for vehicles with IRR camouflage properties	Defence Standard 80-41 Defence Standard 80-166
INT DS 80-209/1	Paint, Finishing, Polyurethane, Multi-Pack, Gloss, Non-Aircraft Use, Low VOC	Gloss finish for Vehicles	Defence Standard 80-50

* These standards will not be withdrawn for the foreseeable future, as there will be a reducing need for these materials over the next few years

These materials are based on chemically curing, high build epoxy and polyurethane resin systems and offer performance enhancements on the single pack materials specified in the older standards. For example, the new paint schemes consist of two coats resulting in lower VOCs and a simplified application process, whilst offering increased durability. However, the use of these materials is significantly different to the older materials. For example, the polyurethane materials necessitate a spray facility with specific ventilation requirements and, therefore, have to be undertaken at approved locations only. Consequently these materials cannot be used as 'touch-up' products, although the improved durability and mechanical performance should ensure that damage and deterioration does not occur as rapidly as in the past. However, DERA has investigated the use of 'touch-up' kits, based on two pack epoxy primer and finish coats, to provide materials for the repair of damaged paintwork.

The development of these standards has proved to be an excellent example of a productive interaction between paint users, equipment support authorities, the Directorate of Standardization, DERA and the paint industry. As a result, the MOD has products available which meet current environmental legislation and demonstrate a commitment to green issues whilst enhancing material performance.

At the international level, NATO are also very interested in using compliant materials, not only to ensure compliance with member Nation's Government regulations, but to increase the confidence and interoperability between individual Nation's products in the Operational field. NATO Committee AC/301 Sub Group B - Standardization of Materiel and Engineering Practices, deals with paint related STANAGs (NATO Standards) and it is currently working on two STANAGs which will specify compliant materials. Both relate to Chemical Agent Resistant Coatings:

STANAG 4360 - Specification for Paints and Paint Systems, Resistant to Chemical Agents and Decontaminants, for the Protection of Land Military Equipment.

STANAG 4477 - Specification for Paints and Paint Systems, Resistant to Chemical Agents and Decontaminants, for the Protection of Aerospace Military Equipment.

At present, both STANAGs as they stand are unsuitable for UK MOD use, but with modification their usability could be increased to a level where Defence Standard's 80-208 & 80-209 could be cancelled in favour of the NATO product specifications. Not only would this be in line with UK MOD Standardization policy, but it would also increase UK MOD's procurement capability.

To further address the reduction of VOC usage during the painting of land vehicles, the supplementary processes involved with painting have been reviewed. Equipment is washed using a water/detergent mix prior to mechanical preparation with only localised solvent degreasing for difficult areas.

Paint spraying application methods are also covered in relevant PGs and to improve transfer efficiency and reduce waste, High Volume Low Pressure (HVLP) is specified

as the minimum acceptable technique. HVLP guns have been introduced and some Army Base Workshops are investing in electrostatic spray equipment with its improved transfer efficiency over HVLP facilities. This offers improvements to both the environment and the paint applicators and the reduction is waste has cost benefits.

With regard to paint removal, land vehicles are stripped using mechanical methods rather than VOC based chemicals.

Additional measures to reduce solvent emissions and waste, involve the use of solvent recovery units to reuse waste materials and enclosed cleaning plants are employed to clean spray guns.

AIRCRAFT PAINTS

A separate PG (PG 6/40 [3]) covers the repainting of aircraft. This document has a range of VOC limits depending on the exact nature of the paint product and examples include the following:

Material	Limit
Epoxy Primer	350g/l
Gloss polyurethane	420g/l
Erosion resistant coatings	800g/l
'Other speciality Coatings'	840g/l

The most commonly used materials by the RAF for aircraft refinishing are epoxy based primers based around the British Standard specification (BSX 33) and matt polyurethane top coats based around the British Standard specification (BSX 34).

The matt polyurethane topcoats used by the RAF are classed as 'Other speciality coatings' due to the necessary camouflage requirements. These have a relatively high VOC limit and current materials meet this level easing the pressure on a significant part of the RAF paint inventory. However, the RAF are evaluating high solids matt polyurethane finish coats for future use so that these products provide a genuine reduction in VOC content.

There are, however, other paints with lower VOC limits (e.g. abrasion resistant coatings) for which compliant materials will need to be identified and evaluated. For the limited number of aircraft requiring a gloss polyurethane finish, the RAF are using high solids VOC compliant finish with less than 420g/l.

Following extensive materials evaluation programmes, the RAF Surface Finishing Authority (SM35f (RAF)) are now using compliant materials for their most commonly used aircraft paint systems with the materials applied using HVLP equipment.

Paint removal on aircraft has traditionally been carried out by chemical methods using dichloromethane based paint removers. Over the last five years the RAF has adopted physical methods of paint removal using plastic media stripping (PMS). Under PG 6/40, dichloromethane based paint removers are not compliant and to cover the areas that still require a chemical stripper, products based on benzyl alcohol, which is a non-VOC materials as defined in the PG, are being evaluated.

Whilst these have been successful with selectively strippable paint schemes, they are generally not effective on conventional polyurethane based aircraft finishes. Further work is required in this area.

Degreasing of aircraft, prior to painting, is another area in which work is ongoing to partially reduce the current reliance on solvent-based products.

On the subject of aircraft paint schemes, but separate to the pressure on solvent reduction is the increasing environmental concern with the use of chromates within aircraft primer formulations. Chromates are extensively used for the corrosion protection they offer to critical non-ferrous based metal substrates, however, the environmental impact of such heavy metals is causing increasing concern. To address this problem experimental paint formulations containing chromate replacements are being assessed against current chromate products by the DERA.

PAINTS FOR NAVAL EQUIPMENT

The Royal Navy has adopted a very proactive response to environmental concerns. In common with the other Services, priority has been placed on the high volume use materials and these include the weatherwork coatings applied to the superstructure of ships, flight deck coatings and paints schemes used on the internal surfaces of vessels. Work has involved laboratory evaluations and ship trials and a paper by Townsend [4] describes, in greater detail, the trial work undertaken.

The laboratory work undertaken to date has concentrated on the evaluation of high solids and water based materials against the Defence Standards covering the weatherwork paint system This material has a number of critical requirements including the achievement, and retention, of high gloss levels. It is also a material that may be applied under adverse conditions using unsophisticated equipment during naval operations. Further work is also underway to investigate coatings used for internal applications and on flight decks and any new coatings introduced into service have to meet future environmental legislation in addition to meeting other technical requirements.

CONCLUSIONS

Environmental legislation has provided a major impetus to introduce new coatings but in addition to the introduction of materials with low solvent contents it has provided an opportunity to introduce materials with improved performance.

This has been shown to good effect in the vehicle finishing area in which the armed forces will have equipment coated with extremely durable two-pack products with enhanced chemical resistance which is a desirable operational requirement for the military.

The work has also highlighted that, in general, the performance of the single-pack products tested do not match that of the current solvent based paints with the high solids samples offering more potential than water based materials at this stage. It should be remembered, however, that water based products are more desirable from an environmental point of view as they reduce solvent levels (VOC content) to the bare minimum.

Although current single-pack materials do not meet the performance required and further product development is needed by paint manufacturers this is readily recognised by the paint industry and all manufacturers are investing heavily in the production of new materials as replacements for solvent based paints. In fact one of the problems with assessing the performance of compliant paint schemes is that laboratory work would commence on the samples supplied by manufacturers and newer improved products would be offered prior to completion - it is a rapidly changing scene.

The impact of the move towards compliant coatings also requires the MOD user to carefully consider the particular purpose of a paint scheme. With solvent based coatings a particular material could be used in a wide range of applications. For example, material conforming with Defence Standard 80-41 is used to paint various military vehicles as well as static ground support equipment sited in the middle of airfields. Current compliant coatings do not show such versatility and in future different materials may need to be used for the different situations. These presents a problem with regard to an increase in the inventory of paints held and may lead to different process instructions for the different materials. It is important that expert advice is sought during deliberations on such changes. It is easy to specify single source, proprietary materials but for continuity of supply, assurance of product quality and to assist with competitive tendering the use of performance standards (e.g. Defence Standards) is essential.

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Note: Defence Standards are obtainable from the Directorate of Standardization, Room 1138, Kentigern House, 65 Brown Street, Glasgow, G2 8EX, UK.
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Environmentally Compatible Coating Removal for Weapon Systems

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The U.S. Department of Defense's depot and sustainment activities produces large amounts of hazardous waste each year in the re-furbishment of all types of military equipment. These include but are not limited to tanks, combat ground vehicles, ships, aircraft and their associated armament. Budgets for new materiel acquisition in all the services have dropped substantially since the early 1990s and services are committed to holding on to their existing inventories of equipment. In one example, the Air Force B-52 Bomber will remain in service until the 2030's, extending its life cycle to over 90 years.

Right now the U.S. is postured in a position to maintain its aging inventory of legacy system equipment. There is no doubt that many pieces of equipment will go through many Re-work cycles until it is placed in surplus. Coupled to the fact that since the end of the Cold War, the U.S. Military has been subject to stringent air and water pollution control through legislation and executive order. The military services which operate the shipyards, air logistics centers and depots now face the two fold challenge of a vastly increased workload and much stricter environmental guidelines of which to operate. In addition, many Government Owned, Government Operated depots face endless cost cutting challenges from outsourcing in the private sector to remain open.

Many of these maintenance operations involve paint stripping and re-painting of vehicles and aircraft. Other operations involve coating removal of inorganic coatings such as those in engines and other assemblies such as landing gear. For example, it is estimated that 80% of the Air Force hazmats are created by painting and de-painting operations alone. Both the Army and the Navy employ extensive means to their painting and stripping operations. These until recently involve conventional means of paint stripping and coating removal that involve chemical and mechanical means. Chemical means using methylene chloride requires elaborate compliance means such as air emissions controls and filtering systems. Occupational health and safety issues are also considered in that personnel must wear protective equipment and receive the proper Hazmat training. In addition, permits must be obtained and inspections by many state agencies in which the depots operate.

Another important point is that many states, in this case California has air emission standards that are far stricter than Federal ones. This is especially true of the SouthCoast Air Emission Standards around the Los Angeles basin and also further south in San Diego. For example, it not uncommon to for the Marines to move trucks and equipment to a neighboring states to strip and paint these vehicles. Again this takes additional time and will increase costs of operations. Hazmats must be stored, cataloged and disposed of properly. Depots are subject to inspections and must comply with paperwork and all this adds up to increased costs of operation.

The traditional approach to the environment is to focus on complying with the law and to clean up wastes that were generated throughout the years. All of this is fine but it can be somewhat shortsighted in that all things being equal, unless one changes the process, hazardous

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materials will continue to be generated. In short, compliance and clean up costs will always remain if not grow due to future legislation. The key is in source reduction by initial elimination or reduction of chemicals. Solutions must also go beyond the environmental compliance issues in that they must make economic sense and have relatively short payback periods.

In military terms, pollution prevention, especially in the area of coating removal is an issue that effect force readiness. Commanders whether at the depot or theater level know that equipment, particularly aging equipment must in top working condition. This means relatively short cycle times and with reliable output. As we shall see in the remainder of this paper, when implementing P2 solutions, this is a major selling point to the Commander.

Many technologies have been implemented in recent years to address pollution prevention concerns. Some have been around for many years but only recently have been used for paint stripping and coating removal. Technologies such as Ultra High Pressure Waterjet (UHPWJ), CO2 Pellet Blasting, Xenon Lamp and Laser Stripping will be addressed in this paper. These processes represent the state of the art in coating removal and some are more in a stage of advancement than others are. The advantages and limitations of each will be discussed along with examples of their applications. Economic considerations will be outlined in a section on Environmental Cost Accounting Methodology. (ECAM). This will be used as objective accounting tool, based on activity based costing to validate the cost savings of these technologies.

UHPWJ has been around for many years and has been employed in the area of precision cutting. Recently, this technology has been applied to surface coating removal. The waterjet is built around an enclosed cell with a programmable robot platform or used manually with a waterjet lance. Water is recycled through the system and through a filtering system, the coating residue is collected into a solid cake. The jet is used at ultrahigh pressures between 30 and 50 ksi for metallic coating removal and the water consumption is about 1 to 3 gallons per minute (gpm). For organic coatings, UHPWJ is used at pressures between 10 and 30 ksi with a 2 to 6 gpm water usage. A rust inhibitor added to the water to prevent corrosion to the stripped part. Variables in using the UHPWJ include the standoff distance, the nozzle rpm and traverse rate.

The result is that parts are stripped in a fraction of the time compared to the existing methods of chemical bath stripping. Also, a fraction of hazmats, (10%) is produced with the waterjet versus the conventional methods. UHPWJ technology is currently applied in production scenarios both at the Army's Corpus Christi Army Depot (CCAD) and the Navy's Naval Air Depot –Jacksonsville (NADEP-JAX). In the case of the former, CCAD is the Army's chief depot for rotary wing aircraft. Not only are the Army's aircraft serviced there, but some Navy and Air Force helicopters also. The facility does service foreign military aircraft of allied and friendly nations.

The T700 gas turbine engine is refurbished at CCAD and it is used in the UH-1 platform. Certain parts of this engine have flame sprayed coatings which must be removed. Until the UHPWJ was implemented, parts were submerged in chemical baths for as much as 8 to 12 hours In addition, the parts had to be abrasive blasted every hour. With the programmable waterjet, parts are stripped in 45 minutes. The resulting time saving represents significant gains in productivity and costs savings. Pay back is less than a year.

In Jacksonville, the Navy services a variety of its aircraft from carrier jets to the Orion P-3 used in offshore maritime patrol. Like CCAD, NADEP-JAX has an extensive Engine re-work facility and has similar production challenges. Here the UHPWJ workcell is used on wide variety of jet engine parts that require coating removal. Parts are stripped in a fraction of the time and

part rejection has dramatically dropped from a 30% to nearly zero and eliminated a bottleneck in operations.

Other applications of UHPWJ include ship hulls for removing paint when ships are in dry dock. Again, the technology must be adapted to that application but the cost savings and productivity gains can be just as attractive. As far as future applications go, waterjet technology is being considered for use in wheeled and tracked combat vehicles. The Army is interested in applied this technology at the field level to rapidly strip epoxy primers and polyurethane paints from combat vehicles. So far, under the direction of the National Defense Center for Environmental Excellence (NDCEE) the preliminary trials have been quite successful.

The next technology application is CO_2 pellet blast media using a high rpm (12000) turbine wheel to accelerate the cylindrical pellets (approx. 3mm diameter and 12mm length) before they strike the surface. Unlike convention dry blast media such as sand or plastic pellets, the media sublimes and only the residual paint remains. One has to remember that when dry blasting, the media such as plastic becomes classified as hazardous waste. Like the UHPWJ, the volume of hazmats created is greatly reduced and also like the waterjet, a programmable work cell is used. The CO_2 gas is ventilated and filtered out of the workcell.

NDCEE has tested this technology at its Johnstown, PA facility on steel coupons and engine container cans supplied by NADEP-JAX. The preliminary results have been most promising and the next step is to transition the technology to full production. The strip rate varies between 36 and 56 ft^2 per hour and is a line-of-sight system. That means the areas in corners and tight spaces that cannot be 'seen' need to be stripped by conventional means. Although small in area, it does take additional time.

Xenon Flashlamp/CO_2 technology was developed by the McDonnell Douglas Aircraft in Mesa, Arizona to service the Army's Apache helicopters and at Kingsville, TX for the Navy's T45 jet trainer. Now part of Boeing, this technology named *Flashjet* has been used on various rotary and fixed wing aircraft as part of technology transition plan. Being ablated by a high temperature xenon lamp strips paint and then a low-pressure stream of CO_2 pellets hit the surface to remove any remainder of coating. The entire residue is then captured by a large vacuum and is stored as waste. The advantages are indeed many, mostly the time saved in rapid paint removal and the exponential reduction of hazardous materials generated by conventional chemical means. Aluminum and composite aircraft skins tend to be somewhat delicate and highly aggressive paint removal can damage the substrate.

This technology is also line of sight and requires some conventional stripping in small areas that the Flashjet lamp cannot reach. The results are still very impressive. An entire aircraft can be stripped in a fraction of the time not to mention the drums of residual methylene chloride. Platforms are being develop to scale up the Xenon lamp to strip larger aircraft such as P-3 Orion. The NDCEE is expected to explore the application of this technology to combat vehicles.

Laser technology is another solution for environmentally compatible paint stripping and coating removal. Recent developments in feedback control and beam stability have improved the process. Unlike a narrow beam used for cutting, this beam is much wider and disperses energy out. The result is clean and quick paint stripping process. Lasers are especially useful on thin skin composites and aluminum and have the ability to selectively strip layers of paint at a time. In other words, if it was just desired to remove the topcoat without removing or damaging the primer coat, this could be achieved. Powdercoat, an extremely hard baked on coating which is

difficult to remove by conventional means, can be stripped using the laser technology. Lasers can be adapted to portable units (hand held) and automated for high production workcells.

Environmentally friendly technologies must go beyond the obvious environmental benefits. Factors such as increased productivity and lower costs are key to them being implemented. To validate the cost savings of these new technologies, the NDCEE in conjunction with Coopers and Lybrand, developed a Environmental Cost Accounting Methodology (ECAM). This methodology is used for the technical professional as a desktop guide to identify those costs associated with implementing some of these environmentally safer technologies. Non-accountants can use the ECAM to define and compare environmental costs. Based on activity based costing ECAM is desired to identify those environmental costs that are hidden in traditional overhead costs.

Environmental costs associated with maintaining a weapon system have been estimated to be anywhere from 10 to 30 percent. The ECAM has been applied to several of these technologies and the results are indeed impressive. To use the UHPWJ as an example consider the following:

Traditional View	**Activity Based View**
Labor	Permitting
Utilities	Training
Materials	Compliance with regulatory requirements
Equipment	Plan environmental strategies
	Operate/maintain environmental equipment
	Treat on site wastes
	Handle/Dispose of Hazmats
	Perform environmental Remediation

To use the ECAM to identify environmental costs to process activities by comparing the old chemical process with the UHPWJ:

Old Process	**UHPWJ**
Handle Hazmats	Dispose/recycle metal cake
Treat wastewater	Provide safety training
Analyze Hazmats	Maintain Material Safety Data Purchase
and Maintain Personal Protective Equipment	Sheets (MSDS)
Maintain Environmental permits	
Maintain MSDS	

The ECAM is a guide is extremely useful in measuring costs which is crucial to the implementation of this state-of-the-art technology. As one would expect the initial capital costs of the UHPWJ can be quite daunting. Engineers must be able to accurately predict short payback periods to justify the initial costs. Under traditional accounting methods, these costs might not be so easily identified. The ECAM allows for these costs to be identified and then can be used in accounting program or software. For more information the NDCEE ECAM is available on the World Wide Web at http://www.ndcee.ctc.com/inframe.htm

Challenges that lie ahead for these technologies besides the initial capital investment are to educate the sustainment community about these cleaner and greener technologies. The equipment discussed in this paper is quite complicated and technology reluctance can be a roadblock to implementation. To be fair, some of the technologies are farther along than others

and is readily adapted to a variety of applications. In this case, the UHPWJ is already in several production applications while CO_2 Turbine Wheel requires some additional work before it is placed in production.

Furthermore, no one technology will solve every coating removal problem. Every application depends of the type of substrate, its configuration and of course, the costs.
As mentioned previously, funds at the depot level are scarce and P2 projects are closely scrutinized.

To re-emphasize the point made earlier, the reality is that P2 must take a large role in environmental decision making. Commanders and their civilian managers must look beyond the compliance and clean issues of the present. Using advanced technologies serious cost reductions can be realized. When this occurs along with increased readiness, real environmental change can occur.

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4) Mr. Jimy Alvarez, Corpus Christi Army Depot, TX
5) Mr. Thomas Landy, US Army Tank-Automotive RD&E Center, Warren, MI

Environmentally Compatible Coating Removal for Weapons Systems

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NATO Environmental Workshop
7 May 1999

Program Outline

- Statement of Problem
- Approach
- Technologies and Production Applications
- Economic/Cost Validation
- Challenges
- Summary

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Problem Statement

- Department of Defense Depot Activities generate large quantities of hazardous materials (HAZMATs) in the painting/depainting of combat vehicles, ships and aircraft
- 80% of Air Force HAZMATs waste created by paint/depainting operations
- Conventional methods costly and time consuming
- HAZMATS expensive to store, monitor and dispose of

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Approach

- Use of cleaner, "greener" technologies for coating removal
- Must go beyond environmental concerns - need for faster, better, cheaper
- Address safety and occupational health issues
- Address issues of airborne particulate, National Emission Standards for Hazardous Air Pollutants (NESHAP) requirements
- Bottomline: Emphasize pollution prevention (P2) by allocating resources to reduce of HAZMAT generation

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Technology Solutions

- Ultrahigh Pressure Waterjet
- Media Blasting - CO_2 pellet
- Xenon Lamp
- Laser Stripping

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UltraHigh Pressure Waterjet

- Uses water spray at 30k to 50k psi to remove flamed sprayed coatings and paint from surfaces
- Used in conjunction with programmable robot workcell
- Closed system which recycles water and collects residue through filtering system

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UltraHigh Pressure Waterjet

- Used in engine parts coating removal
- Program to use in paint removal for combat vehicles
- Removes coating in a fraction of the time
- A fraction of HAZMAT generated Vs. conventional chemical means

UHPWJ Production Applications

- Corpus Christi Army Depot
  - T700 turbine engine parts
  - parts stripped in 45 minutes Vs. 8 to 12 hours by conventional chemical stripping
  - Pay back period approximately a year
- Naval Air Depot - Jacksonville
  - used on jet engine parts to remove coatings
  - 9month payback, 0% part reject(30% before)

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UHPWJ Future Applications

- Project to strip paint off combat wheeled and tracked vehicles
- Remove top coat and epoxy base coat primer
- Goal is to have safer, faster and more effective paint stripping
- Mobile unit being designed and assembled for field use

Media Blast CO_2 Pellet

- CO_2 Pellets are used as abrasive media for paint and organic coatings
- Pellets shot at surface from high velocity turbine wheel (12000 rpm)
- Used in conjunction with programmable robotic arm
- Media evaporate and leave paint residue only
- Tested in stripping paint from engine container cans and test coupons using a variety of coatings

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Xenon Lamp

Combines high temperature Xenon lamp with CO_2 pellet blast media.

- Extreme temperature differences shatter coatings, vacuum captures residue
- Time savings - Can strip large aircraft in fraction of the time
- Cost savings in labor (masking) and storage/disposal of HAZMATs

Laser Stripping

- Has been investigated in the past to remove inorganic and organic coatings
- Recent technology improvements in feedback control and power and beam stability
- Potential for great applications especially on more delicate substrates like composites
- Has great applications to remove very hard coatings such as powdercoat

Environmental Cost Accounting Methodology (ECAM)

- Developed by the National Defense Center for Environmental Excellence in conjunction with Coopers & Lybrand
- Based on Activity based costing
- ECAM collects total environmental costs, especially those hidden in traditional overhead costs
- Tool for non-accountants to define and compare environmental costs
- Applied to coating removal projects
- Web site: http://www.ndcee.ctc.com/inframe.htm

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Challenges

- Clean coating removal technologies contain initial high capital costs
- Some technology reluctantance, both depots and configuration managers
- Funding for full implementation
- Educate community to emphasize P2 and away from strictly compliance and clean-up

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Current Status

- UHPWJ in use at CCAD and NADEP-JAX
- UHPWJ workcell being developed for paint removal on vehicles
- CO_2 is being explored for a variety of surfaces
- Xenon lamp being developed for aircraft and vehicles
- Laser stripping workcell in use at CCAD

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Summary

- Many approaches to problem of stripping which depend on:
  - Substrate
  - Configuration
  - Cost
- Some technologies more mature than others
- Specific application and requirement dictate which method

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- Mr. John Speers Air Force Laboratory WPAFB, OH
- Mr. Jimy Alvarez, Corpus Christi Army Depot, TX
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INVESTIGATIONS INTO RISK ASSESSMENT AND COST ANALYSIS AS TOOLS FOR POLLUTION PREVENTION DURING MILITARY EXERCISES AND TRAINING

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ABSTRACT

Military forces are big and diverse organisation with heavy demands for equipment, chemicals and other materials when conducting training, exercises and day to day missions. Military forces are also producers of large quantity of hazardous and harmful wastes, which in the field conditions can have strong negative influence on the environment. Many of these wastes are similar to those of large civilian industrial organisations, but some are peculiar to the army mission.

The main purpose of the presentation is to show ideas developed for estimation of environmental loses and costs resulting from military exercises and training activities of land troops, navy and airforce. The legislative, economic and technical tools, which lead to the minimisation of the environmental damages during the military training and exercises, are discussed. Types of military training activities and materials, which have the most severe environmental impact, have been identified.

Furthermore, the paper describes measures undertaken within the military sector to face the environmental standards and regulations relating to national guidelines on air, water, soil, and nature protection during the military training and exercises.

1. INTRODUCTION

Military forces are big and diverse organisation with heavy demands for equipment, chemicals and other materials when conducting training, exercises and day to day missions. Military forces are also producers of large quantity of hazardous and harmful wastes, which in the field conditions can have strong negative influence on the environment. Many of these wastes are similar to those of large civilian industrial organisations, but some are peculiar to the army mission. For example military forces have major responsibility for energetic materials – propellants and explosives, different kinds of fuels and for NBC training.

The main purpose of the presentation is to show ideas developed for estimation of environmental loses and costs resulting from military exercises and training activities of land troops, navy and airforce.

It is well recognised that military training and exercises performed on different military training areas, facilities and installations results with negative environmental impact.

Paper presented at the RTO SAS Symposium on "Approaches to the Implementation of Environment Pollution Prevention Technologies at Military Bases", held in Budapest, Hungary, 5-7 May 1999, and published in RTO MP-39.

2. LEGISLATIVE MEASURES

During last ten years the approach of Polish Ministry of Defence to the environmental issues has diametrically changed. Though the activities of Polish Armed Forces in the field of environmental protection have been conducted for more then twenty years nevertheless sometimes they haven't been carried out with full understanding and in the proper way. Today it is fully accepted that military training and exercises have to be conducted with the agreement to the environmental law and with the responsibility for the nature preservation.

Nowadays activities of Ministry of National Defence take place in more restrictive requirements of national and local environmental legislation. Exact execution of the responsibilities of users of environment is controlled by the State Inspectorate of Environmental Protection, which can even stop the exploitation of firing ranges and other military training facilities, which don't fulfil environmental standards. Polish Ecological Law treats the military sector in the same manner as other users of the environment.

The article 5 of the Constitution of the Republic of Poland of 6 April 1997 specifies *"Republic of Poland guards independence and indivisibility of its territory, ensures freedom and human rights and safety to its citizens, guards national heritage and ensure environmental protection, leading by sustainable development principle".*

In the article 26 the Constitution states *"The Armed Forces of the Republic of Poland serve to protect the independence of the State and the indivisibility of its territory as well as to ensure the security and inviolability of its borders".*

We see that according to the highest law military activity must always be considered in an ecological context and environmental requirements, whenever it does not weaken military preparedness. Environmental impact of the military training and exercises is not a new matter, however general awareness of significance of the problem is relatively new and it is quite difficult tasks to be fulfilled by Ministry of Defence alone.

Nowadays Polish Ministry of National Defence fully realises the adverse environmental and human health impacts of military activities (training and exercises). Having that in mind, always whenever it does not diminish military performance, military sector complies with all articles of environmental law and regulations established for civilian sector in Poland.

Poland, like the majority of other countries, has extensive and comprehensive environmental legislation, which has evolved over years. Especially, since the United Nations Conference on "Human and Environment" in Stockholm in 1972 and "Environment and Development" called *Earth Summit* in Rio de Janeiro in 1992 have taken place. In accordance with standing legal order in the Republic of Poland, the Armed Forces are subject to all normative regulations universally valid in the State. Moreover, environmental liability refers both to military organisations and to personal liability of the commanders, at all levels of command.

The Act on Protection and Shaping of the Environment of 31 January 1980 in article No 89 impose normative obligation to ensure conditions that are vital to accomplishment of environmental protection regulations. According to the legislation, Minister of National Defence is obliged to create organisational and legal conditions for complying with environmental protection regulations. Council of Ministers Decree of 9 July 1996 also obliges the Minister of National Defence to ensure the compliance with the requirements of environmental protection within the military sector.

Regulation on environmental protection in military sector of 1975 issued by the Minister of National Defence concerned planning period of 1975-1990. Hence three five-year plans had been developed, approved and implemented up to 1990. In Poland primary act on environmental issues is already mentioned *Act on Protection and Shaping of the Environment* of 1980 amended in 1994. The Resolution of the Polish Parliament on the *State Ecological Policy* of 1991 was also a milestone event in evolving the process of Polish environmental legislation.

As far as environmentally related legislation in Poland is concerned, Polish Armed Forces should accomplish all principles and rules like any other governmental or commercial civilian organisations do.

Polish Armed Forces, as crucial for successful environmental performance, have identified following areas:

- environmental risk assessment on each military installations;
- remediation of polluted areas;
- ecological education of both military and civil staff;
- environmental audits carried out in all of the military organisational units;
- provide conditions to assure environmental and health safety
- creation new financing sources and instruments for environmental performance in military sector;
- reduction adverse environmental impact of military training and exercises;
- creation of ecological data base necessary for conducting processes of command, planning, and executing of the tasks

Successful meeting of environmental requirements needs adequate legal procedures to assure effective inspection of compliance with environmentally relevant legislation on military training areas and installations. This issue is regulated by the *Act on State Inspection of the Environmental Protection* of 1991 (*PIOŚ*) and Minister of National Defence *Decision of 1996 on circumstances of render military installations availability to State Inspectors*.

In 1997 Minister of National Defence and Minister of Environmental Protection Natural Resources and Forestry signed an agreement, on co-operation in the field of environmental protection. The agreement is expected to create new financial instruments for environmental projects undertaking in the military training areas, firing ranges and other facilities. There are also provided conditions for use of forestry areas for military training and other defence-related purposes.

3. POLISH ARMED FORCES AS THE USER OF THE ENVIRONMENT

Armed Forces, due to its peculiarity and carried-out tasks, use the environment within two aspects, which result in contamination, damage and emission of pollution. Firstly, the armed forces use the environment to support its primary military mission. Secondly, military sector, like any other governmental organisation, uses the environment to meet living needs as accommodation, food and welfare facilities.

Successful meeting the primary military mission needs to maintain equipment, store armaments and, first of all, have high skilled soldiers to operate the military equipment. Soldiers must have the opportunity to perform exercise and training in realistic conditions. Armaments and equipment must be tried and tested in the field. Hence training with high concentration of people, equipment and hazardous materials has to have an adverse impact on the environment. The question is how to control the impact, limit it and restore occurred environmental damages.

One of the stipulations of accomplishing of the established aim is the acceptance of the following, main environmental protection principles within the training activities of the Armed Forces:

- organisation of environmental protection is the duty of the commanders at every command level;
- environmental protection is the obligation of each soldier and employees of the Ministry of National Defence;
- implementation of the principle of reduction of negative influence on environment in the process of training troops, as well as planning and carrying out other defence related tasks;
- ecological education is an integral element of every form of training and education in the Armed Forces;
- rational utilisation of natural resources and reduction of negative effects of troops training and accommodation on the environment.

Military training, technology and equipment causing the necessity to reconcile two contradictory, for the armed forces, tendencies:

(1) intensification of training troops, especially of combat training, by making its conditions similar to the real ones and taking advantage of all the possible means of simulating;
(2) ensuring the protection of forests, soil, air, water and plants from pollution and damage caused by training activity.

There is a wide range of military training activities having adverse impact on the environment. The Ministry of National Defence in Poland identified following military facilities and areas of significant environmental influence:

- operational and reserve airfields;
- fuel storage depots and pipelines;
- naval harbours and radar stations;
- central testing grounds, firing ranges and exercise fields;
- garrison firing ranges and exercise fields;
- ammunition storage facilities;
- operation facilities such as: car and tank washing stands, battery rooms, paint shops, electrovining plants, workshops;
- garrisons with barracks, headquarters and residential areas.

Military sector provides soldiers with means to meet their necessities of live, such as accommodation, food, welfare facilities, recreation. These uses of the environment by military sector create similar environmental problems to that caused by civilian urbanised areas.

Finally, speaking about the Armed Forces as a user of the environment we must remember that military sector has not only adverse impact to the environment. Despite the military exercises the training grounds of Polish Armed Forces and, in particular, the large troop training grounds are known as very well preserved areas with unique flora and fauna. A number of threatened animals and plants have found their habitation on desert areas controlled by the armed forces. In general it can be stated that the last or even larger local populations of animal and plant species which have otherwise disappeared, or which become extremely rare exist on military training areas. The numerous and valuable biotopes which can be found on our military training grounds are a clear indication that military occupancy and nature conservation have not to be incompatible.

4. REDUCTION OF ADVERSE ENVIRONMENTAL IMPACT OF MILITARY TRAINING AND EXERCISES

The basic objective of environmental protection in the Armed Forces is to ensure ecologically safe conditions during carrying out defence related tasks. The way to accomplish this objective is the implementation of the main principles of environmental protection, as well as realisation of pro-ecological tasks by all of those in the Armed Forces, who use the environment both militarily and economically.

Only limited works has yet been undertaken at Armed Forces sites to register and assess contamination of soil and groundwater. Surveys of petroleum products storage depots indicated that only few of the them were equipped with basic spill emergency facilities. Moreover, approximately 40% of petrol, oil and lubricants distribution facilities have been more than 30 years without any protection measure. As a consequence, investigations at sites (in particular airfields) showed the presence of contamination of both soil and water environment with fuel and lubricants.

The other source of soil and water contamination is wastewater generated at military sites. About 6% of sewage volume are discharged to so-called "Dumping grounds" without prior treatment. Significant amounts of poorly treated wastewater are discharged into surface water resulting in degradation of their quality.

Recent surveys and inspections of storage areas and areas where hazardous substances are used or handled indicated neither any violation of Polish environment protection regulations nor threat to people or the environment.

The following actions are planned or have been already undertaken in order to prevent further soil and water at military training areas in Poland:

- Installation of leakage monitoring systems at fuel and chemicals storage depots;
- Replacement of disused storage tanks and distribution facilities;
- Sealing handling areas of petroleum products;
- Installation of anti-oil dams, bilge water and sewage collection systems at naval bases;
- Safe processing of hazardous solid wastes;
- Recycling of used equipment and materials;
- Organisation of a monitoring network based on automatic contamination measurements, data transmission and processing;
- Forestation and reforestation by trees and shrubs planting.

Remedial action has mainly been limited to installing measures, which stop spreading the pollution and prevent future damage. Projects related to the decontamination of polluted in the past soil or groundwater have virtually not been undertaken except for emergency situations such as uncontrolled spills in areas of utilised groundwater resources, as – for example – it was the case at the Pila airfield, where jet fuel had spilled.

Environmental performance in the Polish Armed Forces is recognised as a priority and has been included into the "Project on Modernisation of the Armed Forces in 1998-2012" accepted by the Government. Budget of Ministry of National Defence destines 180 millions zloty for implementation of environmental projects in the field of military infrastructure, including general infrastructure, airfields, naval, transportation, training and special infrastructure. Additional funds are expected from the National Fund for Environmental Protection and Water Management of 30 millions zloty in the period of 1998-2002 and 60 millions zloty in 2003 - 2012 years.

Polish Armed Forces developed following projects to accomplish targets and priorities established by the State Ecological Policy of 1991:

A. Project on energy save in military installation by the year 2000

It is assumed as target substantial reduction of energy consumption by approximately 25 to 30%. What in consequence should result in the reduction of fuels consumption and carbon dioxide emission by approximately 20 to 25%.

Such results will be achieved by:

- Thermal upgrading of the buildings;
- Replacement of the heating network with pre-insulated pipes;
- Retro-fitting of the coal fuelled boilers;
- Liquidation of small boilers which through outdated technology are hazardous to the environment.

B. Project on improvement of maintain and operation facilities.

This project defines scope of necessary repair and retro-fitting work at the car and tank wash stands, battery and painting plants, galvanising and oxidising plants, so it will be possible for these facilities to achieve environmental protection requirements. It is very important because of necessity improving low technical condition of these facilities, which harmful influence to the environment is serious. For example 3 years ago over 40% of lead battery plants didn't meet the basic requirements of environmental protection.

C. Pilot project on environmental protection planning and management of training areas.

It is expected that outcomes from the pilot project on environmental protection planning and management of training areas. The result of the project will became a base to formulate detail orders for carrying out military exercises on all training areas in a way that ensure accomplishment of environmental requirements and sustain use of the training area. The pilot project consists of three stages, as following:

- preparing documentation about the state of the environment and inventory of existing facilities both military and civilian;
- developing of concept of further use of the training areas in the coming 20 years, which would fully satisfy military performance and meet environmental requirements and standards;
- analysis of obtained data will help in elaboration an order on environmental protection precaution at the training area.

D. Project on fuel and grease storage areas (in the period of 1996-2000).

During the realisation of that project we assume remediation of contaminated soil and ground water and elimination sources of contamination. After the first research stage of that project we spent approximately 1.5 mil. USD. Expenses connected with remediation of airfields are difficult to estimate in, and they are still analysing.

E. Project for protection against the noise on airfields

Realisation of that project is based on the study and implementation of systems reducing the level of noise in the areas of airfields. So far it was elaborated and implemented such a project for one airfield, and for the next two there is in the course of work.

5. EDUCATION

Successful implementation of the environmental program in the Polish Armed Forces is strongly dependent upon a well-qualified workforce. For this purpose we established program and system of ecological education and training. This system covers every segment of the Armed Forces at all levels from the top commanders to each soldier. Ecological education in the Ministry of National Defence is based on the military command and control system and is a part of entire education system of all officers and soldiers.

Everyone in the military must be aware of his/her ecological responsibility and take action in case of necessity. Our goal is, that each member of the military society should be trained so that he/she can meet the environmental responsibilities associated with his/her job and activity. The program is based on different levels of education: recruit training, special training, professional military education, continuing education for environmental professionals and education of senior leadership. Each soldier is obliged to attend 20 hours courses of environmental education. Last year the Ministry of National Defence has issued one thousand of posters and ten thousands of brochures devoted to the environment protection. Further 60 thousands brochures will be issued this year. The modern environmental handbook for Armed Forces will be issued by the end of this year.

Postgraduate education and training courses for civilian and for commissioned officers have been conducted at Military University of Technology (since 1988), at The National Defence Academy (since 1992) and at the civilian Main School of Farming in Warsaw (since 1992). Altogether more than eight hundred specialists have completed these post-graduated studies. A number of specialists have successfully competed environmental courses at the NATO school in Oberammergau.

6. RESEARCH AND DEVELOPMENT

The huge amount of ecological tasks in Armed Forces needs developing new branches of knowledge and new technologies. The military sector is seeking for alternative materials and technologies that meet performance requirements specific to the military activities, with less adverse environmental impact than materials and technologies currently in use.

On the other side the problem of safe disposal the old military equipment and munitions, acid battery, used oil and chemicals, as well as remediation of contaminated soil and groundwater need new, cost effective and socially acceptable processes and technologies.

Ministry of National Defence and the Scientific Research Committee arranges financial support for developing modern technologies and techniques including those for soil and groundwater remediation. A number of new material technologies and remediation techniques are now being tested at a laboratory and pilot scale.

For example, the following environmental-related technologies and techniques have been recently tested:

- Application of surfactants for washing of contaminated soil;
- Removal of hydrocarbons from contaminated soil by means of desorption;
- Groundwater decontamination by physicochemical method
- Noise reduction system;
- New simulation and training technology;
- Reduction of fuel consumption and lowering toxic emission;
- Development of advanced and environmentally friendly materials.

However, in Poland is still a significant demand for new technologies and remediation techniques. Implementation of new, environmental friendly, technologies and techniques has not only positive ecological aspect but also positive economic effect.

7. CONCLUSIONS

Military training and exercise should always be considered in an ecological context. Environmental protection is not a primary task of the Polish Armed Forces and neither it will be, but the Polish Armed Forces are ready to assist in conserving the environment in their own sphere and to avert dangers to the environment outside of the armed force.

We believe, that the implementation the environmental friendly means during the training activity will result with the reduction of negative environmental impact of troops training on air, soil, forests, ground water, and surface water and thereby will reduce costs of military training. The way to accomplish these objectives is the implementation of the main principles of environmental protection, as well as realisation of pro-ecological tasks by all of those in the armed forces, who use the environment both militarily and economically.

Airborne Sensor Survey for the Detection of Hazardous Substances and Objects in the Subsurface.

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1 Introduction

In recent years there has been a surge of interest in methods for a rapid and reliable detection of unexploded ordnance (UXO) and other hazardous substances and objects in the subsurface. In Germany much of the motivation comes from recent environmental protection projects for the investigation and clean up of former military and industrial sites. The tremendous size of these areas to be investigated made it necessary to find innovative methods to get a rapid view of the contaminations for upcoming planning tasks and also to minimize the costs for necessary ground based surveys and clean up.

Having been the prime contractor for a large project for the investigation of the contamination of more than 1000 former military sites of the West Group of the Russian Troops (WGT) in Eastern Germany the IABG gained an valuable amount of information and knowledge about the problems of the clean up of hazardous waste on military sites. As a result IABG started a research and development project using airborne sensor systems for the survey and detection of hazardous substances and UXO in 1997. This project is partially funded by the Federal Ministry of Education and Research. Parallel to IABG´s R&D project and in close cooperation with IABG another federal institution did similar reasearch but with other airborne sensor systems. Both R&D projects will end in spring 1999 with final reports due in mid 1999. After publication by the German Environmental Agency (UBA) the reports will be available for the public.

2 Scope of Work

The main goals of the R&D projects are the investigation of

- the usefulness of various airborne sensor systems
- the improvement of used systems and software
- the determination of the limits of the used systems

for the detection and assessment of various types of hazardous waste and UXO. The detection of unexploded ordnance was not the main goal, but at least with the system used by IABG this investigation was a important aspect.

In the R&D project several survey techniques were used, among them

- aerial imagery,
- magnetic and electromagnetic geophysical sensors,
- multispectral (MSS) and thermal scanner.

Paper presented at the RTO SAS Symposium on "Approaches to the Implementation of Environment Pollution Prevention Technologies at Military Bases", held in Budapest, Hungary, 5-7 May 1999, and published in RTO MP-39.

All systems were installed in or at the bottom of a helicopter including ancillary equipment such as real time differential corrected Global Positioning System (GPS) navigation and data positioning, laser and radar altimeter.

3 The WGT Project

In the „Treaty between the Federal Republic of Germany and the Union of Soviet Socalist Republics on the Conditions of Limited Residence and the Modalities of the Scheduled Withdrawal of the West Group Troops (WGT) from the Territory of the federal Republic of Germany" as well as in joint declaration of Chancellor Helmut Kohl and President Boris Yeltsin in Moscow on 16th December 1992, the withdrawl of the former Soviet troops was settled for the period between 1991 and 31th August 1994. More than 1000 real estate properties with a total size of approx. 243.000 hectars (ha) were returned, divided up into different sized lots (from 100 sqm to 25.666 ha), being of different structures and of various types of utilisation. At the beginning of 1991 the former Federal Ministry of the Environment. Nature Conservation, and Nuclear Safety in agreement with the federal Ministry of Finance commissioned the determination and evaluation of the residual load sites on all above mentioned real estate properties of the WGT. This project was being carried out under the leadership of IABG together with 30 partner companies located in the new federal states. Of the properties investigated, 529 had already been used as military bases before 1945. More than 33.000 residual load sites were registered. The suspected residual load sites recorded can be divided into the following main groups according to the waste and contamination found:

- operational substances (fuels and lubricants)
- ammunition and explosives
- burials of waste and earth movements
- scrapyards
- residue of burning processes
- indiscriminate dumpings
- waste water and sewage sludge
- miscellaneous

The estimated quantity of all contaminants on the WGT properties were about 2.95 million tons with approx. 1.3 million tons mineral waste, 750.000 tons metal scrap, 456.000 tons residental waste, 126.000 tons of mineral oil products, 100.000 tons organic waste, 83.000 tons of earth movements, 20.000 tons of explosives and ammunition, 8.180 tons of organic chemicals.

Another result of the investigation of the WGT sites was, that there are areas not only with contamination on the surface but also in the subsurface. In addition often times a detailed groundbased survey was either not possible without endangering the survey team or the size of the area would cause an explosion of the costs for a ground based survey.
In 1992 IABG presented a detailed concept as well as practical demonstration of ground based and airborne sensors for the survey of residual load sites within the WGT project. However, the detection of hazardous waste objects and UXO in the subsurface was not part of the WGT project.

4 Aerogeophysical Research & Development Project

In a R&D project started in 1996/97 IABG and BGR did the above mentioned aerogeophysical survey with different sensor systems on two areas (TÜP Jüterbog / Heidehof, TÜP Lieberose), all situated on former Russian military sites in eastern Germany. Among the areas flown were

- a tank bunker,
- military garbage dumps / scrapyards,
- two training areas for chemical warfare and

- two test sites prepared by IABG with various types of ordnance, debris and underground pipeline (2500 kg to 2 kg) typical of active sites.

The test site in Jueterbog/Heidehof was made up of 13 areas each 50m x 50m of size. The single areas contained e.g.

- 12 steel barrels (each 120 litre volume)
- 6 barrels
- 4 barrels
- 2 barrels
- 1 barrel
- metal scrap
- various ammunition
- 1 metal tank (1.2m diameter, 2.4 m long)

Airborne survey was done in the summer of 1997 and 1998. In the time between the flights the measurements were evaluated and interpreted thus providing necessary information for the further development and optimization of the sensor systems and the used algorithms and software for the data processing.

In the R&D projects described here, the following airborne methods were used:

- measurements of the earth´s magnetic field
- electromagnetic induction (EM)
- multispectral scanner

Before the airborne measurements a geodetic survey was done for the areas to be surveyed including the set up of identification marks. After each survey airborne imagery was taken. In addition aerial imagery from the WGT project was available for most areas.

After the data processing and interpretation a ground based survey has to be done for the verification of some areas. This verification will be finished by the end of April 1999.

5 Ground Based Survey Methods

The common investigation of contaminated sites is done on the ground. For large areas products from a remote sensing survey, such as aerial imagery, in combination with a geodetic survey using GPS ore differential GPS are used for the registration of the geographic position of contaminated points or areas. In addition, ground based survey may be necessary (if possible) for the verification of an airborne survey. The methods of ground based survey are well known. For the detection of hazardous objects and UXO in the subsurface geophysical prospecting methods are mainly used. Among these methods are:

- Electromagnetic induction measurements (EMI, EM), taking advantage of the different conductivity of layers in the subsurface
- Electromagnetic reflectance (EMR, Geo-Radar)
- Measurements of the earth´s magnetic field or of its gradients using portable magnetometers

6 Remote Sensing Survey Methods

Besides ground based methods for the investigation of contaminated sites airborne or satellite based methods provide information about contamination on and below the surface. With various sensors measurements and images can be taken in various frequencies of the electromagnetic spectrum. Among these methods are:

- Satellite imagery (black/white (b/w), color, multispectral, radar)
- Airborne imagery (b/w, color, color infrared (CIR), radar)

- Airborne geophysical survey (EM, Magnetic field measurements)
- Multi- and Hyperspectral Scanner Imagery (from about 380 nm to 2450 nm)
- Thermal and Thermal Infrared Imagery (800 nm to 14000 nm)
- Laserspectroscopic measurements
- Gammaspectroscopic measurements
- Stereoscopic Imagery and Laser Scan measurements (for Digital Elevation Models)

Some methods will provide indirect information about contamination or are necessary for optimizing the interpretation of data using another method. Hyperspectral scanners can deliver data in up to 128 multispectral bands with a spectral resolution of 12 - 16 nm and a spatial resolution below 3 metres gained at flight height of 1250 metres. High resolution stereo scanners gather multispectral data plus stereo imagery with a spatial resolution of 15cm to 20cm at flight heights of 400 metres. This enables the calculation of high resolution Digital Elevation Models (DEM) with pixels sizes of 0.5 metres or less. Multispectral imagery can give important information about contamination on the earth´s surface. This may also be an indication of contamination in the subsurface.

7 Geophysical Methods

It is fairly easy to find buried hazardous substances or UXO using ground based metal detectors as long as the objects looked for contain a certain degree of metal. An important problem in ground based range remediation today is discriminating between buried UXO and clutter or other hazardous waste. The sensors which reliably detect subsurface objects with metal components are magnetometers and electromagnetic induction (EMI).
For very large areas, such as shooting grounds or training areas a ground based survey is a very expensive and time consuming action.

The legitimacy for an airborne instead of an ground based survey usually is:

- having a large or very large are to investigate
- having complicated topopgraphy of the area
- neccessity to get a quick overview of the geological layers
- ground based survey is not possible without danger for the survey team
- to get a quick and cost effective overview of the contamination
- to detect the main areas with accumulations of hazardous waste and UXO to optimize / minimize ground based survey

Thus, results from an airborne survey should help to optimize the planning of ground based surveys and clean up activities thus minimizing the costs for these tasks.

7.1 Helicopter based electromagnetic survey

The electromagnetic methods (EM) measure the changes and anomalies of the electromagnetic fields caused by differences and changes in the conductivity of the subsurface. The EM will register very well the lateral variations of the geology. This method is mainly used for hydrological tasks and groundwater mapping. The depth penetration is 50 metres and more. Within the EM active and passive methods are used. The passive method uses signals transmitted from a radio station or from a submarine transmitter (producer of the primary electromagnetic field). The active method has transmitter and receiver combined in the sensor system. The primary field induces electric currents in the conductive zones and layers in the earth thus generating a secondary field, which will be converted within the sensors receiver into an electric signal and registered. The aim is the determination of the distribution of the electric conductivity in the subsurface. The reciprocal is the specific (electric) resistance. If groundwater is contaminated the specific resistance will show lower values than in groundwater not being contaminated.

In the mentioned R&D project BGR concentrated on using and optimizing their EM system. This system together with a single magnetometer is installed in a cigar-type container hanging on a cable about 20m - 30m below the helicopter.

A new construction of an multifrequency EM-system with five frequencies was used:

- 375 Hz
- 1972 Hz
- 8600 Hz
- 41000 Hz
- 195000 Hz

The newly added high frequency enables a better resolution of the region close to the surface.

A detraction of EM-measurements can always occur due to

- instabilities in the compensation of the primary field, e.g. through forces upon the sensor system by temperature etc.
- changes in the external magnetic field (power lines, solar flares)
- bad quality of the calibration (calibration done on high conductive subsoil)
- unprecise split of the measured secondary field into „inphase - and quadrature"-components

In addition to the EM-signals further parameters were recorded

- atmospheric disturbances (spherics)
- position of the helicopter and the sensor system (GPS)
- flight altitude (radar)
- barometric altitude
- time intervals (fiducials)

In the project the interpretation of the measurements could be optimized due to

- using five instead of three frequencies in the EM system
- using a higher scan rate (10 per sec instead of 4 per sec)
- a new calibration concept for the sensor system
- a better noise-to-signal ratio of the new system
- a stable compensation of the primary field
- using newly optimized algorithms
- using a new GPS system in the helicopter

The use of five frequencies instead of three caused better results in the computer aided modelling.

For an overview of the hydro- and geological situation on both areas (approx. 200 sqkm) EM-sensorflight were done with a line spacing of 150m or 200m. The mean height of the sensor was 25m above ground. The test site in Jueterbog/Heidhof and some larger areas (approx. 86 sqkm) were surveyed with a line spacing of 50 m.

7.2 Helicopter Based Magnetic Survey

Magnetometers are being used to measure the total field intensity of the earth magnetic field and, if used in a combination of several magnetometers, the change of the field, the vertical or horizontal magnetic gradient. The vertical component of the spatial gradient, or simply the gradient, is obtained by differencing two simultaneous measurements of the magnetic induction and dividing it by the sensor separation. For example, the geomagnetic field has an average magnitude at the earth´s surface of about 40.000 nT to 60.000 nT (1 gamma = 10^{-5}

= 10^{-5} oersted = 10^{-9} webers/M² = 10^{-9} tesla = 1 nano tesla or nT). All field strength values are reported in nT, all spatial gradients of the field are reported in nT/m.
There are regional variations of the geomagnetic field plus time variations with periods of seconds, minutes and hours as direct or indirect effects of the solar wind distorting the magnetosphere or external magnetic field. Daily or diurnal variations are not predictable and may exhibit changes ranging from 10nT to 1000 nT or more. Therefore a ground based magnetometer is used to measure the local diurnal changes during a campaign. Magnetic anomalies in the earth magnetic field are caused by two different kinds of magnetism: induced and remanent (permanent) magnetization. The remanent or permanent magnetization is often the predominant magnetization (relative to the induced magnetization) in many igneous rocks and iron alloys. It depends upon the thermal, mechanical and magnetic history of the specimen, and is independent of the field in which measured. Induced magnetization refers to the action of the field on the material wherein the ambient field is enhanced and the material itself acts as a magnet (such as UXOs, steel barrels, tanks, etc.).

Aeromagnetic surveys were conducted by IABG on several areas on the Jueterbog and Lieberose sites in 1997 and 1998 for a total of about 2 - 3 weeks in each year.
Survey areas for this campaign were the same as mentioned above for the EM survey. In addition a second test site with 10 areas, 50m x 40m each, was built up in Lieberose in summer 1998. This test site contained

- 3 barrels
- 2 barrels
- 2 x 1 barrel
- metal scrap
- UXO-like iron with masses ranging from 35kg to 1.9 kg

Metal content of 35kg and 11kg represent the metal content of the majority of the shells (granades) found on the WGT site. The orientation of all objects within the earth´s magnetic field was changed for each flight thus having measurements for most of the possible positions of the objects.

For the 1997 survey IABG used two magnetic sensor systems. The so-called X-wing system and the HM3-system. In 1998 only the HM3 was used for survey at the Lieberose site.

The X-wing system is a 3-gradiometer sensor system with four Geometrics cesium magnetometers each separated by a distance of 1.5 metres in a configuration like an X. The sensors are built in a container similar to the EM-system being towed 30 meters below the helicopter. The X-wing system will measure the total field strength and the total gradient (analytic signal) of the local geomagnetic field.

The HM3 system is a newly developed sensor system (Helicopter Mounted Magnetic Mapping System) first used in 1997. This system is using 3 Geometrics cesium magnetometers each placed at one end of three (6 m long) plastic tubes. All tubes are fixed to the bottom of the helicopter, one at starboard, one at port and one showing out at the front of the helicopter. This way you have 3 magnetometers each six meters apart.
The following parameters were measured:

- total magnetic field
- local magnetic anomalies
- diurnal magnetic variation
- other influencing fields (helicopter)
- flight altitude (laser & radar altimeter)
- position of the helicopter using differential GPS

A ground based GPS station was placed on geodetic surveyed positions to enable dGPS measurements.

The scan rate of the HM3 is 1000 Hz. In further steps of the data processing the data were scanned in 20 Hz. This is necessary to reduce noise signals generated from the helicopter and from the earth´s atmosphere by destructive interference. The IABG owned Bell LongRanger 206 had been thoroughly tested and measured in IABG´s large Magnetic Field Simulation Facility (MFSA) normally used for checking satellite systems before launching them into space.

The raw data gathered with the HM3 contain 9 different signals measured. The necessary correction using the measurements of the diurnal variation, sensor and helicopter altitude and position and other parameters is done with an optimized standard software package OASIS *montaij* from GeoSoft. This package contains a separate software module for UXO target analysis from magnetic data.

8 Results

With the X-Wing as well as with the HM3 system all objects in the test site at Jueterbog / Heidehof including the pipeline were detected during the 1997 survey. To find out the limits for the detection of subsurface objects the HM3 system was used in 1998 and the second test site in Lieberose was filled with object much smaller in size and weight than for the 1997 test site in Jueterbog / Heidehof.

Thanks to the new and unique helicopter mounted magnetic mapping system the navigation, maneuverabilty and flight height of the helicopter and the sensor system could be optimized compared to using the X-wing system. With the HM3 system survey lines were interleaved so that the three traces of the magnetic data collection for each flight line provided a nominal spacing of 3 metres with flight heights ranging from 15 m down to 2.5 metres. These parameters were certainly a main factor in gaining usable signals from all objects, even from smaller objects, e.g. a 5.3 kg iron, that could not be detected by airborne surveys in the past.

The EM system used by BGR detected many of the objects buried in the Jueterbog/Heidehof test site. Despite a sensor height of 25m above ground improved postprocessing and filtering algorithms made it possible to definitely improve the evaluation and interpretation of the EM and magnetic signals measured.

In addition the combination (overlay) of recent and historical aerial imagery, thermal, MSS (multispectral scanner) and magnetic data within a geographic information system (GIS) leads to a more reliable and precise interpretation of the measurements.

The final interpretation of the data taking in consideration the still to be processed ground based verification data as well as the final report will be finished in June 1999.

Compared to former airborne surveys using EM or magnetometers sensors the results gained so far during this R&D project with the improved or new systems and methods already show quite some remarkable improvements for the detection of hazardous substances and objects (like UXO) in the subsurface.

DISPOSAL OF PYROTECHNIC ILLUMINATING AND SIGNALLING AMMUNITION

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Abstract

Pyrotechnic illuminating and signalling ammunition is subject of a natural aging because of the chemical behavior of the used pyrotechnic compositions and sub-assemblies. For this reason the durability is limited and the use for its purpose is not longer possible because of the safety aspects.

From the substance properties of the pyrotechnic compositions in illuminating and signalling ammunition starting points are given which lead the disposal to an environmental friendly, extensive recycling of materials. Started from a short description of the design of illuminating and signalling ammunition and the disposal task the practicise diposal processes are demonstrated in a general view.

The exemplarey disposal of pyrotechnic ammunitions in the plant of a German enterprise demonstrates the manifold problems and their solution at the completion of a contract for disposal.

By means of real measurement results for the emission situation the requirements of the environment protection, the approval process according to the German law and the experiences from the operation of the plant are explained.

A special attention is drawn to the engineering solution as well as the measuring technique in context with the emission control.

Finally a view is given to the actual problems of the disposal of illuminating and signalling ammunition.

1. Objectives of Pyrotechnics Disposal – Illuminating and Signal Ammunition

Pyrotechnics are generally described as products with which a flash, smoke, noise or other effects are produced, either for pleasure, as in the case for firework, or for military or technical purposes. These effects are produced via the chemical reaction of solid matter mixtures, that is, the pyrotechnic charges.

The tradition of fireworks reaches back over two thousand years to the cultures of ancient China and Greece, and both these countries also used pyrotechnical charges for military purposes.

A pyrotechnical charge is the determining constituent of a pyrotechnical product, and is composed of solid combustible matter and an oxidiser, together with binding agents and combustion moderators, which all help to produce the effects desired via self-sustaining combustion.

Pyrotechnic mixtures represent explosive charges, which means that the appropriate precautinary measures must be observed, not only during handling in general, but also in respect of cleanless during manufacture and disposal. Pyrotechnical charges are manufactured in accordance with exact formulations, and the chemical composition is analysed during the manufacture and processing stages.

In so far as pyrotechnical products are not used, in other words fired in accordance with regulations, they are subject to the influences of temperature and humiditiy, and therefore a natural ageing process. There is therefore a requirement for disposal of products which have been stored in excess of their shelf life, or otherwise become unserviceable.

Paper presented at the RTO SAS Symposium on "Approaches to the Implementation of Environment Pollution Prevention Technologies at Military Bases", held in Budapest, Hungary, 5-7 May 1999, and published in RTO MP-39.

The alterations in the substance structure and, under certain circumtances, the chemical composition of pyrotechnic charges, which go hand in hand with the ageing process, can lead only to desensitising, but also to sensitisation of the products. Such processes must be taken into account when handling pyrotechnic charges during disposal.

Pyrotechnic products, however, are not classified as waste in the generally accepted sense, but as products with defined properties, in other words, products defined with regard to their chemical and explosive properties. Any disposal of pyrotechnical products in accordance with the regulations applying to hazardous waste must therefore be ruled out, due to classification of these products as explosive charges.

Pyrotechnic production waste in the form of faulty batched, scrapped material, dust from sweepings or secondary materials which have been treated with explosive charges, such as paper of plastic, pose a separate disposal problem. On the one hand, factory safety must be ensured during the manufacturing process by a strict system of residual material detection, separation of individual substances and safe handling of materials. On the other hand, this system must ensure the strict definition of the materials to be disposed of, and enable the preliminary treatment of these materials, for example in the form of a desensitising process, as and when required. The discussion will, however, not be entered to in this paper.

The subject in this paper concerns the problems arising out of the disposal of pyrotechnics produced for military purposes.

A number of recycling and disposal concepts for pyrotechnical products have been developed by various companies over the last few years, and introduced in connection with the disposal of the superfluous inventory of the former East German Army. These concepts ensure not only the most extensive recycling of the constituents, but also fulfilment of the requirements with regard to the handling of explosive charges and environmental protection.

In the course of the performance of this disposal task an a large technical scale, and its extension to the inventory of pyrotechnic ammunition of the Bundeswehr and the armed forces of other states stored in excess of their shelf life, many facts have been established and valuable experience gained.

It has become apparent that the task of pyrotechnics disposal, which includes the following classes of explosive ordnance, must take different methods of disposal into account when concepts demanding the most extensive utilisation of materials are introduced:

- Pyrotechnic illumination and signal ammunition and agents
- Simulation agents, in particular battle noise simulation charges
- HC smoke agents
- RP and WP smoke agents
- Other incendiary agents
- Pyrotechnic agents containing HE
- Propellant powder
- Igniters, in particular those containing Hg

Starting form the exact supervision, determination and classification of the explosive ordnance received for disposal, a most extensive breakdown of the products with separation of invidual constituents is required. Figure 1 refers. The next stage involves the recirculation of residual material in the cycle of materials.

Due to the presence of explosive charges, pyrotechnic constituents, which are generally non-recyclable, must be subjected directly, or following appropriate preliminary treatment, to disposal by combustion in special facilities. Other disposal procedures have, however, been developed with regard to special cases and are applied to the disposal process.

With regard to the disposal of the pyrotechnic constituents of the pyrotechnic illumination and signal ammunition discussed within the framework of this presentation, only combustion facilities in various states of completion can, as a rule, be taken into consideration.

A comparison of the requirement or separation with the feasibility of subsequent material sales underlines the fact that no other solution is possible with regard to the disposal of pyrotechnic charges or pellets. The one exception is black powder in bulk form, which can be used for fireworks.

The groups of substances to be disposed of, together with the disposal steps required in connection with a simple detonation charge, are provided in diagram form at Figure 2. The types of explosive substances obtained during disposal are provided at Figure 3.

2. Disposal Facility Concept

The recycling of pyrotechnic constituents, in other words of pyrotechnic charges, is, as a rule, not possible, either for safety reasons or cost factors. Pyrotechnic constituents are therefore either converted under closely supervised conditions in accordance with handling regulations, or subjected to combustion in a combustion facility. All dust particles and combustion gases generated during these processes are drawn off and input to a waste gas purification facility.

During the process, the natural properties of pyrotechnical charges, that is the capability of self-sustaining combustion due to the „built-in“ oxidiser, together with alkaline effects of the alkaline and alkaline-earth metal solid oxides and carbonates formed, are used to support combustion and waste gas purification.

The concept of a combustion disposal facility is determined not only by the predicted mass throughout of the components, but also by the components to be disposed of. The concept of a comprehensive combustion facility is included at Figure 4. Processes can be eliminated according to the individual field of application.

The combustion facility conceived solely for the disposal of pyrotechnics in the Pyrotechnik Silberhütte Company includes the following component groups. Figure 5 and 6 refer.

- *Combustion Facility*

  Conversion of pyrotechnic charges at combustion temperatures between 2,000 and 3,000 degrees centigrade.

- *Air Condenser as Quench*

  Reduction of waste gas temperature and simultanious preliminary separation and combustion protection.

- *Jet Impulse Bag Filter*

  Alkaline dry purification and dust separation

- *Emission Monitoring Test Section*

  Continuous determination of emission relevant values

- *Induced Draught Fan with Waste Air Chimney*

All dust particles generated are filled via discharge facilities into sheet steel barrels, which are currently stored in an underground waste dump. Although further treatment of filter dust particles is planned, realisation of the process is at present not possible due to the current costing structure in force with regard to recoverable substances.

The input of substances for combustion ist performed via an automatic input facility for safety reasons.

A facility for the recycling of pyrotechnic products such as one described is subject to the Federal Immission Control Act, as are all pyrotechnic facilities.

Although open combustion is specified in current regulatios for explosives factories as a requirement for operational authorisation, new ground is broken by a combustion facility with integrated waste gas purification. Initial operating experience has shown not only that a reduction in emissions has been achieved, but also that pecularities in the operation of the facility demand special operating methods which deviate distinctly from those currently in use in hazardous waste incineration facilities.

Since approximately 80 – 90 per cent of pyrotechnic substances input to combustion is converted to alkaline dust particles, the separation of these particles is the main problem with regard to the purification of waste gas.

The disposal procedure described in this paper is based on the principle of conformity between the reaction conditions in the facility and its operation in accordance with regulations, together with the avoidance as far as possible of any transfer to other media during the waste gas purification stage. It is for this reason that open combustion and dry waste gas purification, in other words, a procedure dispensing with the use of water, was chosen.

Fulfilment of the emission value requirements of the Federal Immission Control Act, Regulation 17, was demonstrated within the framework of the authorisation procedure.

3. Procedural Principles and Results of Emission Monitoring

Typical compositions of pyrotechnics used for military purposes are as follows:

Mg	48 %	Composition „yellow“
$NaNo_3$	43 %	
Mg Stearate $[Mg(C_{18}H_{35}O_2)]$	2 %	
Varnish $[C_{16}H_{26}O_2]$	8 %	

Mg	29 %	Composition „red“
KNo_3	14 %	
$SrNo_3$	40 %	
PVC $[(C_2H_3Cl)_n]$	10 %	
Varnish	7 %	

Mg	40 %	Composition „green“
$Ba(No_3)_2$	40 %	
PVC	15 %	
Varnish	5 %	

There are also the following combustible compositions in form of black powder:

KNo_3	75 %
S	10 %
C	15 %

Finally, there are various intermediate charges, for example:

Mg	16 %
KNo_3	75 %
Novolak $[CH(C_6H_4OH)_2]$	9 %

Taking the „yellow“ main charges and a requirement for total conversion as an example approximately 900 g/kg solid combustion products are generated, for example MgO, K_2O, Na_2O, together with approximately 315g/kg gaseous constituents. Estimated as a percentage of the original pyrotechnic charge, these figures amount to approximately 90% in form of solid matter, and 10% in the form of gaseous constituents.

The existence of complicated conditions can be inferred from the actually recorded values of the gas analysis and the ash and filter residue, however.

An overview of emission ratios recorded to date in respect of pyrotechnics with the composition Me-MeNitrate is included at Table 1. These ratios based solely on the gas measurements recorded in the combustion facility.

It will be clear that the test data are effected to a great extent by the operating conditions of the facility, in other words by the temperature of the facility with regard to the generation of thermal NO_x, as well as by the oxygen available with regard to the conversion of CO.

With regard to the open combustion of pyrotechnic ammunition in accordance with regulations, this means that the conditions conducive to the generation of NO_x and CO are much more favourable, that is to say, less NO_x and CO are generated than in an established combustion facility. The analyses of filter dust and slag discharge provided the values which were to be expected.

The alkaline and alkline earth elements used are recovered in the form of oxides, carbonates, nitrites, nitrates and, in certain cases, chlorides. Carbide can also be found under certain conditions.

Only traces of heavy metals were recorded. This assumes, of course, that such metals are not present at the start of combustion cycle, for example CuO or $SbSO_3$.

An eluate analysis of filter discharge and ash residue of the above compositions is included in Table 2. A (theoretical) computer projection of filter dust composition based on analyses results is included at Table 3.

The precense of Strontium is not critical. No Sr^{90} was recorded !!!

Soluble barium compounds in the form of semi-toxic substances are transformed in practice into sulfates or carbonates an then immobile.

This problem, together with the high solubility, must be taken into account when filter and ash residue is dumped.

Table 3: Results of the Filter Dust Analysis

Coarse Dust:			
MgO		- 46.8	Percentage Weight
$(Na/K)_2O$		- 14	"
SiO_2		- 9	"
$MgCO_3$		- 9.3	"
H_2O		- 8.5	"
Fe_2O_3		- 3.7	"
$CaCO_3$	- 2.3	"	
$SrCO_3$		- 1.5	"
Al_2O_3		- 1.4	"
$SrSO_4$		- 1.4	"
$BaSO_4$	- 0.8	"	
$(Na/K)Cl$		- 0.6	"
$ZnCO_3$	- 0.4	"	
Fine Dust:			
MgO		- 67	Percentage Weight
$(Na/K)_2O$		- 14.3	"
$MgCO_3$		- 7.0	"
$BaCO_3$	- 4.4	"	
$SrCO_3$		- 3.1	"
$(Na/K)Cl$		- 1.6	"
H_2O		- 1.6	"
$BaSO_4$	- 1.0	"	
$(Na/K)Cl$		- 0.6	"
$ZnCO_3$	- 0.4	"	
Dioxin / Furan Toxicity Equivalency iaw NATO		- 0.2 ng/kg	

Selected facility operating data is presented in the following figures. A history of daily averages for a typical month is presented at Figure 7. A typical history of half-hourly mean value is presented at Figure 8.

The combustion behaviour of bulk pyrotechnical charges, for example detonation charges, must be analysed prior to their disposal. Charges of sensitivity grouping 4 or 5 can be directly input to a combustion facility in small amounts, for example smoke charges containing HCH. Charges with a higher speed of reaction must be desensi-tised prior to combustion. Desentisitation can be effected either by the addtion of en-doergic agents, or by converting the oxygen constiuent into supercritical form. The participation of desentisiting agents in combustion reactions in connection with the generation of waste products must be taken into account. This applies also to the effect of inert agents.

The occurence of stable reactions must be ensured in every case. In addition, the technical devises used in the input and combustion processes must be capable of preventing a reaction at the input position and therefore a hazard to personnel and the facility itself.

4. Conclusions

The following conclusions can be stated:

1. Procedures have been developed for the recycling of pyrotechnic products, including combustion of the pyrotechnic charges, and are currently being applied.

2. Additional investigations have demonstrated that the procedures are also suit- able for the combustion of bulk pyrotechnic charges.

3. Immission control requirements in accordance with Regulation 17 of the Fede-ral Immission Control Act can be fulfilled.

4. Constituent reprocessing procedures can be used with regard to special forms and configurations of pyrotechnic products.

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Figure 1 : *Pyrotechnics Disposal Diagram*

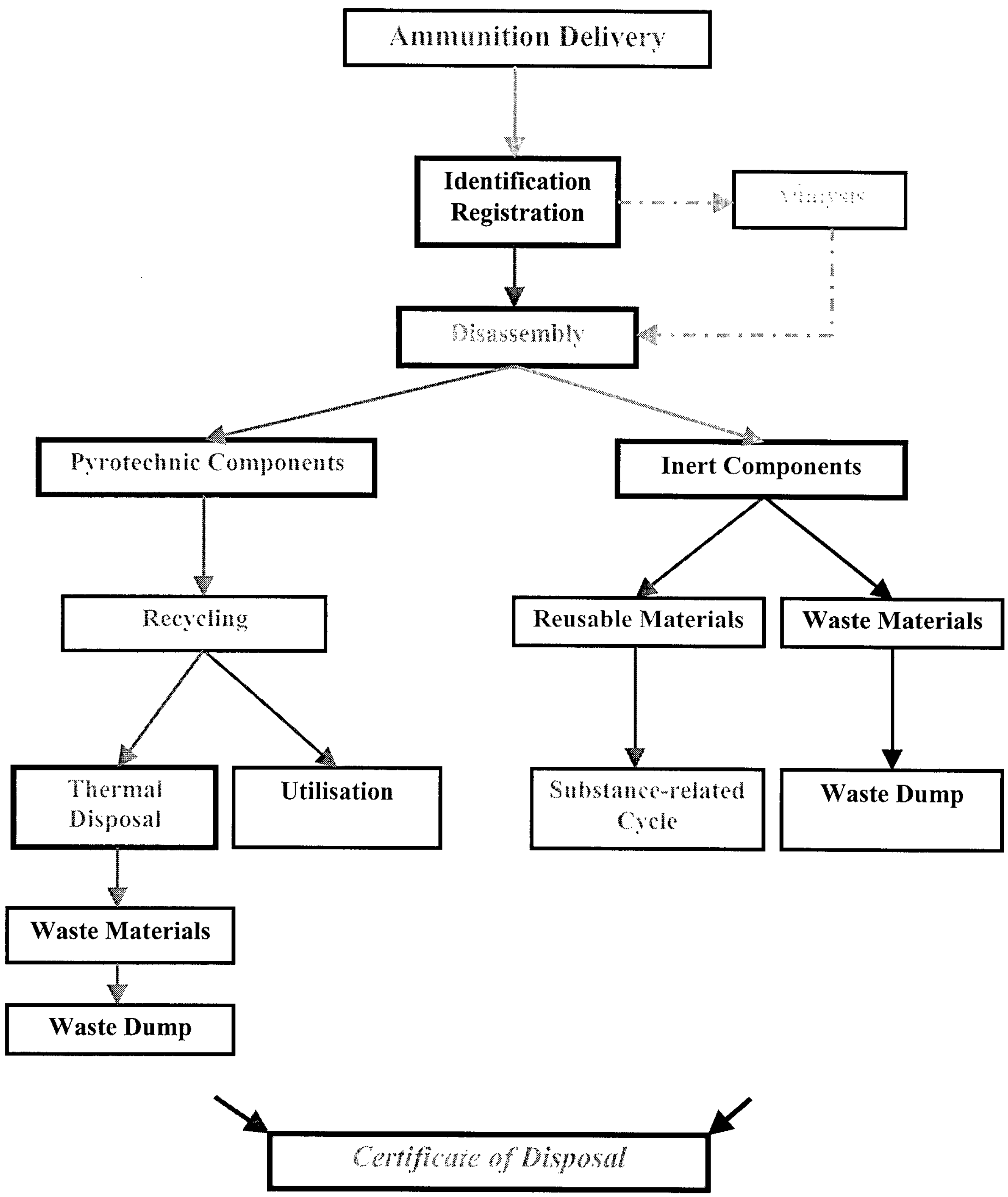

Table 1: Gas Composition Based on Gas Measurements Alone

Composition	NOx	CO	V	m	STB*)	SO_2	HCl	Total C	TE
	mg/m³	mg/m³	m³/h	kg/h	mg/m³	mg/m³	mg/m³	mg/m³	ng/m³
„Yellow"	258±50	7.5±0.8	6939±1081	73	0.19±0.04	1.57±0.18	1.20±0.8	2.35±0.93	0.002
„Red"	47±15	24±12	7685±623	74	0.17±0.01	1.63±0.06	0.39±0.02	0.08	-
„Green"	47±11	13±6	7251±400	89	0.17±0.02	1.54±0.11	0.45±0.05	2.46±1.74	0.004
„Yellow2"**)	178.4	29.4	5458	94	0.0	2.58	n.g.	n.g.	n.g.

*) - Solid Particle Ratio 92.8 %

**)- Mean Values recorded on 22 March 93

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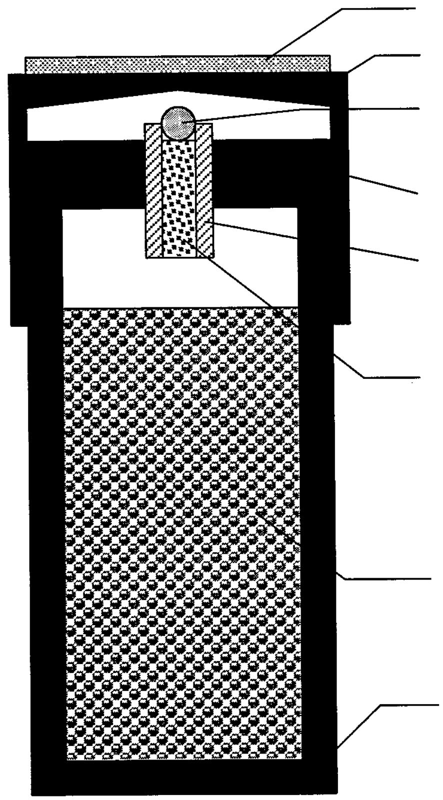
Table 2 : Results of Eluate analysis of Solid Combustion Products

Composition		yellow		green		red
Dust	Dimension	coarse	fine	coarse	fine	fine
pH-Value		11.62	12.73	11.52	12.92	12.98
Conductivity	mS/cm	18.6	40.1	14.9	47.8	49.0
Lead	mg/l	< 0.01	< 0.02	< 0.01	< 0.01	< 0.01
Copper	mg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Mercury	mg/l	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Cadmium	mg/l	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Zinc	mg/l	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Chromium	mg/l	< 0.01	< 0.05	< 0.01	< 0.01	< 0.02
Chromium (IV)	mg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nickel	mg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Vanadium	mg/l	< 0.01	< 0.01	0.17	0.21	< 0.01
Antimony	mg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cobalt	mg/l	0.01	0.02	< 0.01	0.09	0.02
Arsenic	mg/l	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Thallium	mg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Tin	mg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Selenium	mg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Barium	mg/l	14	31	8050	9500	8.2
Ammonium	mg/l	10.6	< 0.5	2.44	0.64	< 0.5
Chloride	mg/l	37	130	4700	6900	7400
Nitrate	mg/l	0.85	8.5	< 0.1	1.6	5.4
Nitrite	mg/l	< 0.2	9.8	< 0.2	0.25	< 0.2
Sulphate	mg/l	131	282	< 0.5	< 0.5	630
Fluoride	mg/l	0.1	< 0.1	< 0.1	< 0.1	0.26
Cyanide (perturbed)	mg/l	< 0.03	< 0.03	2.6	0.03	< 0.03
AOX (perturbed)	mg/l	< 0.01	< 0.01	< 0.01	0.19	0.22
TOC	mg/l	< 5	< 5	< 5	< 5	< 5
PAH iaw German Drinking Water regulations	mg/l	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001



Friction Surface	- Paper, RP-Mix
Cap	- Cardboard
Igniter	- Pyrotechnic Charge ($KClO_3/Ba(NO_3)_2/S/Binder$)
Plug	- PVC-Moulding
Delay tube	- Brass
Delay tube charge	- Pyrotechnic Charge (Black Powder)
Detonating charge	- Pyrotechnic Charge ($Al / KClO_4$)
Case	- Cardboard, impregnated with Phenolic Laquer

<u>**Figure 2 :**</u>

Thunderflash

Assembly

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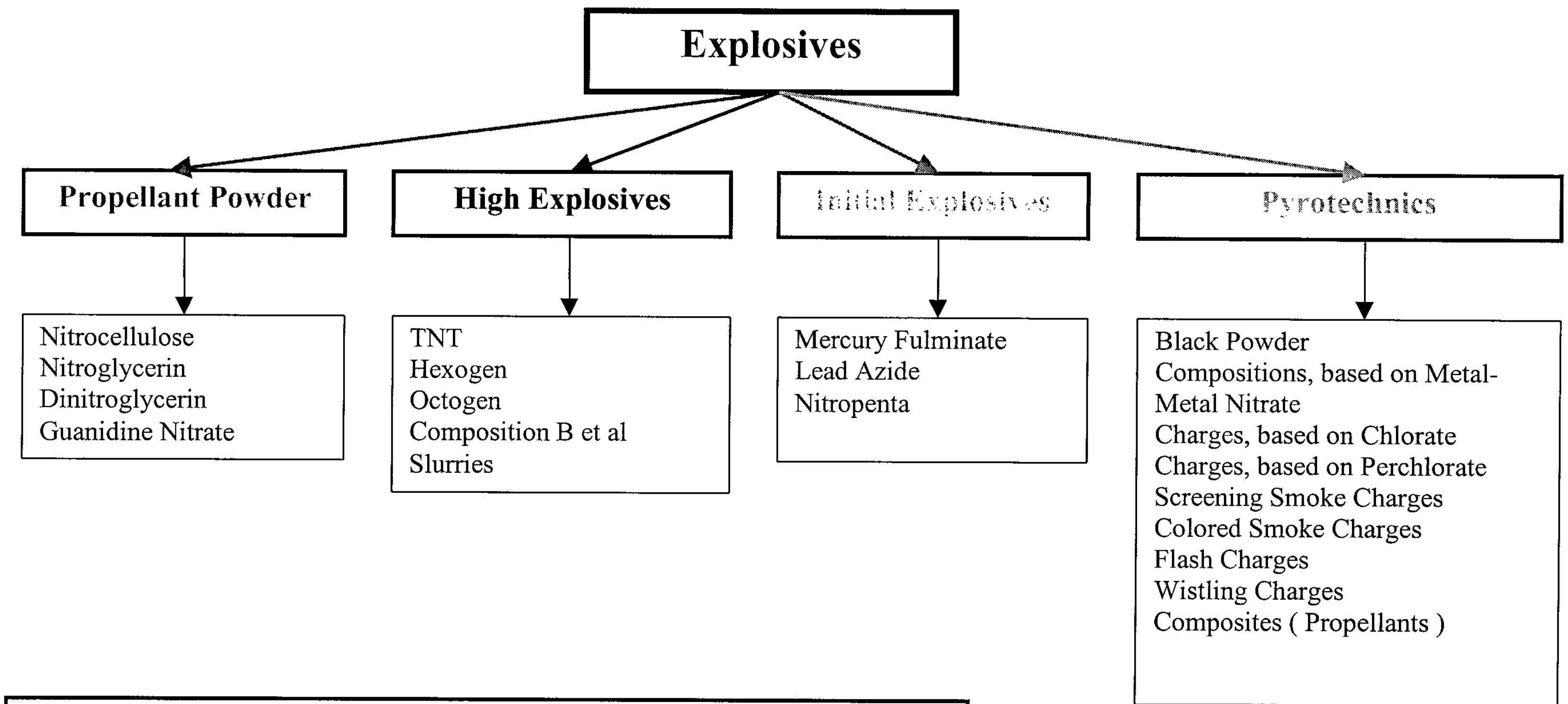

Figure 3 :

Explosives Recovered during Explosive Ordnance Disposal

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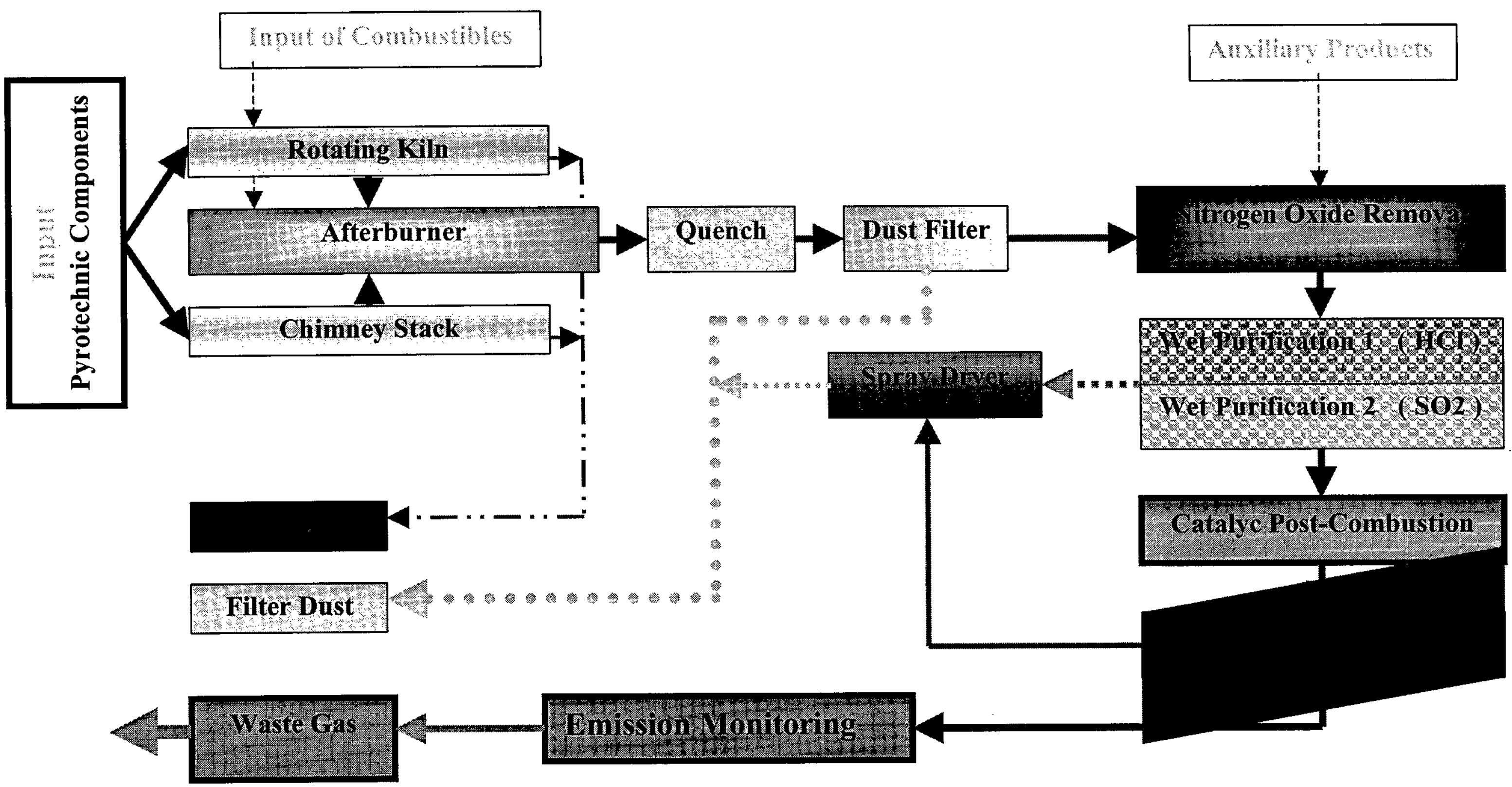
Figure 4 : Thermal Disposal Facility Diagram



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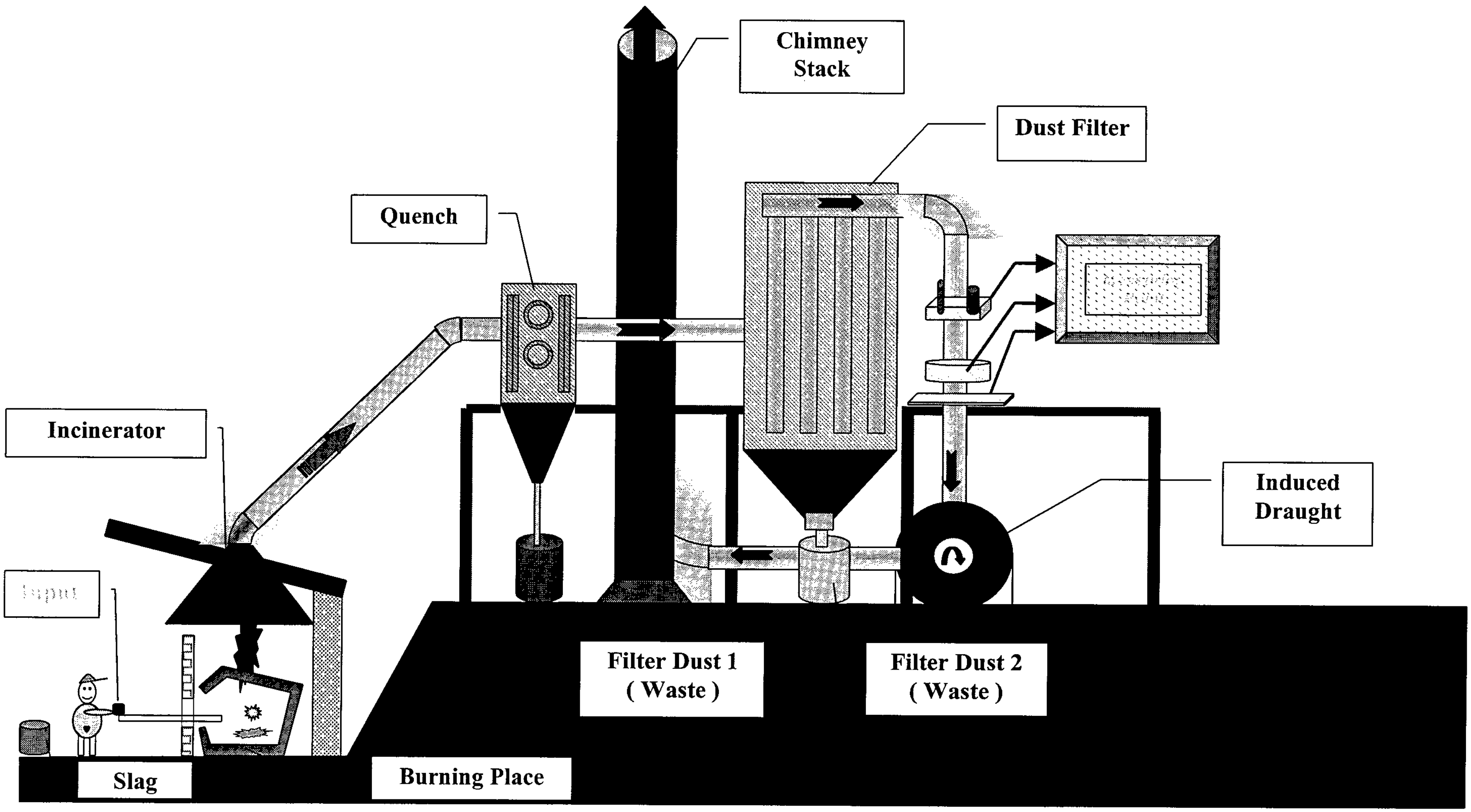
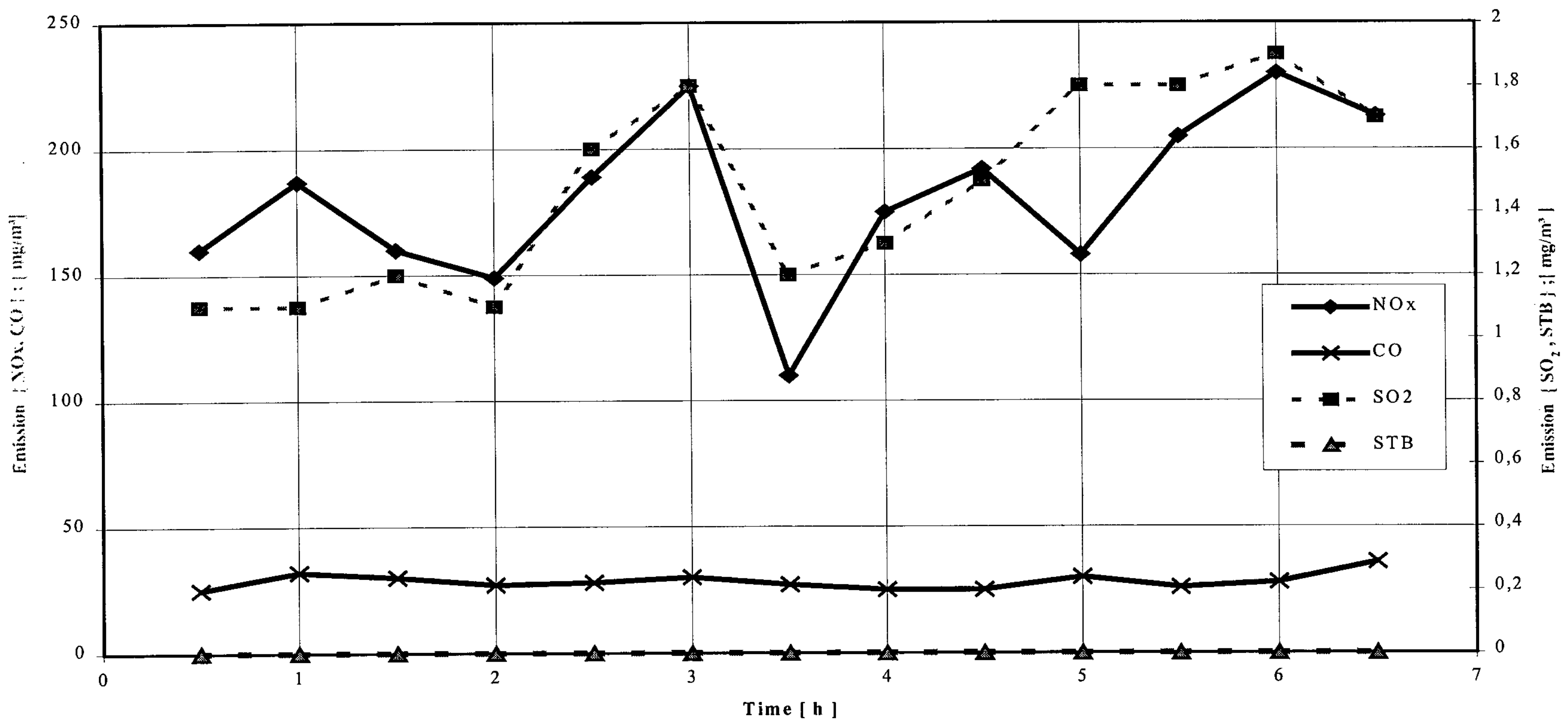


Figure 5 : *Thermal Utilisation Diagram - Silberhütte Facility*

Picture 8 : *Emission Values (Half-Hour-Values)*



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Picture 7 : *Emission Values (Daily Mean Values)*

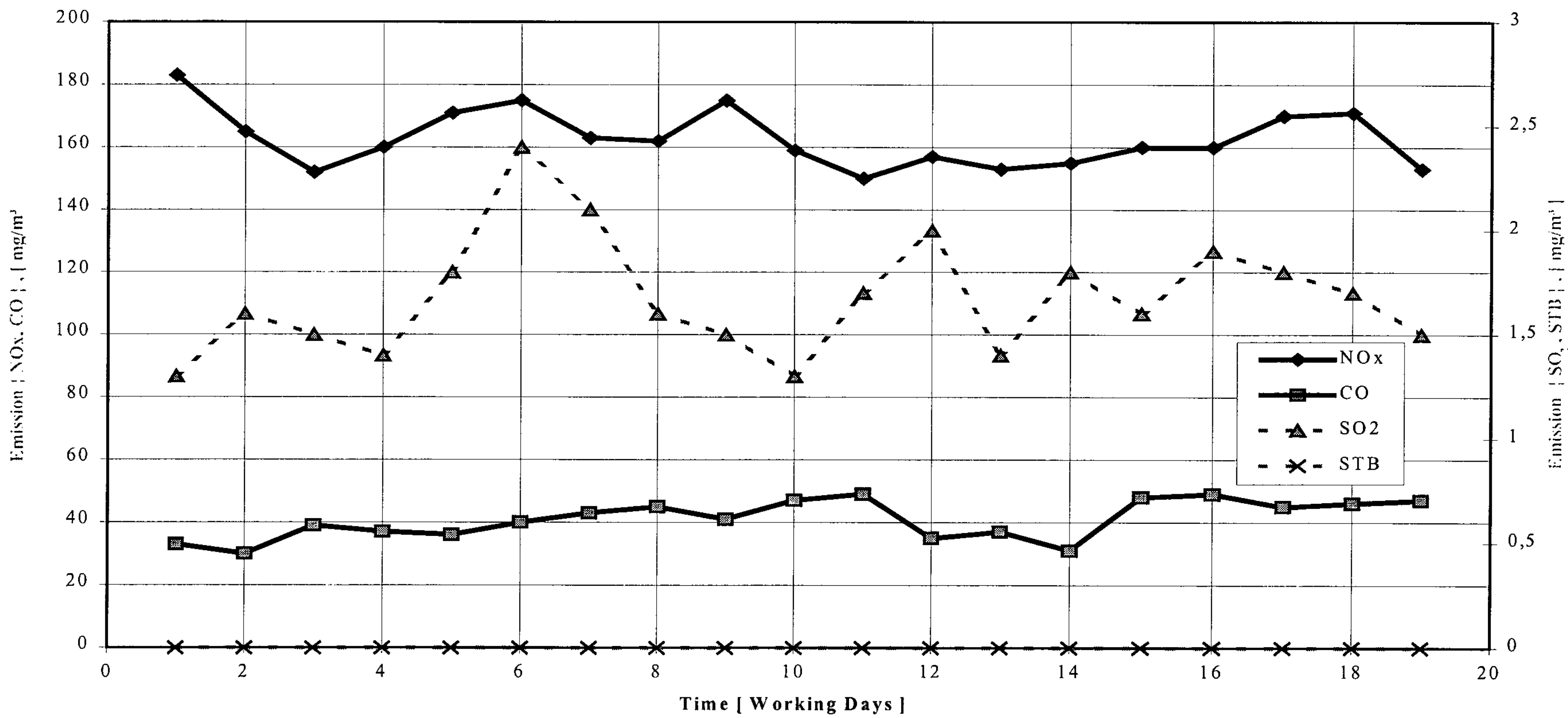
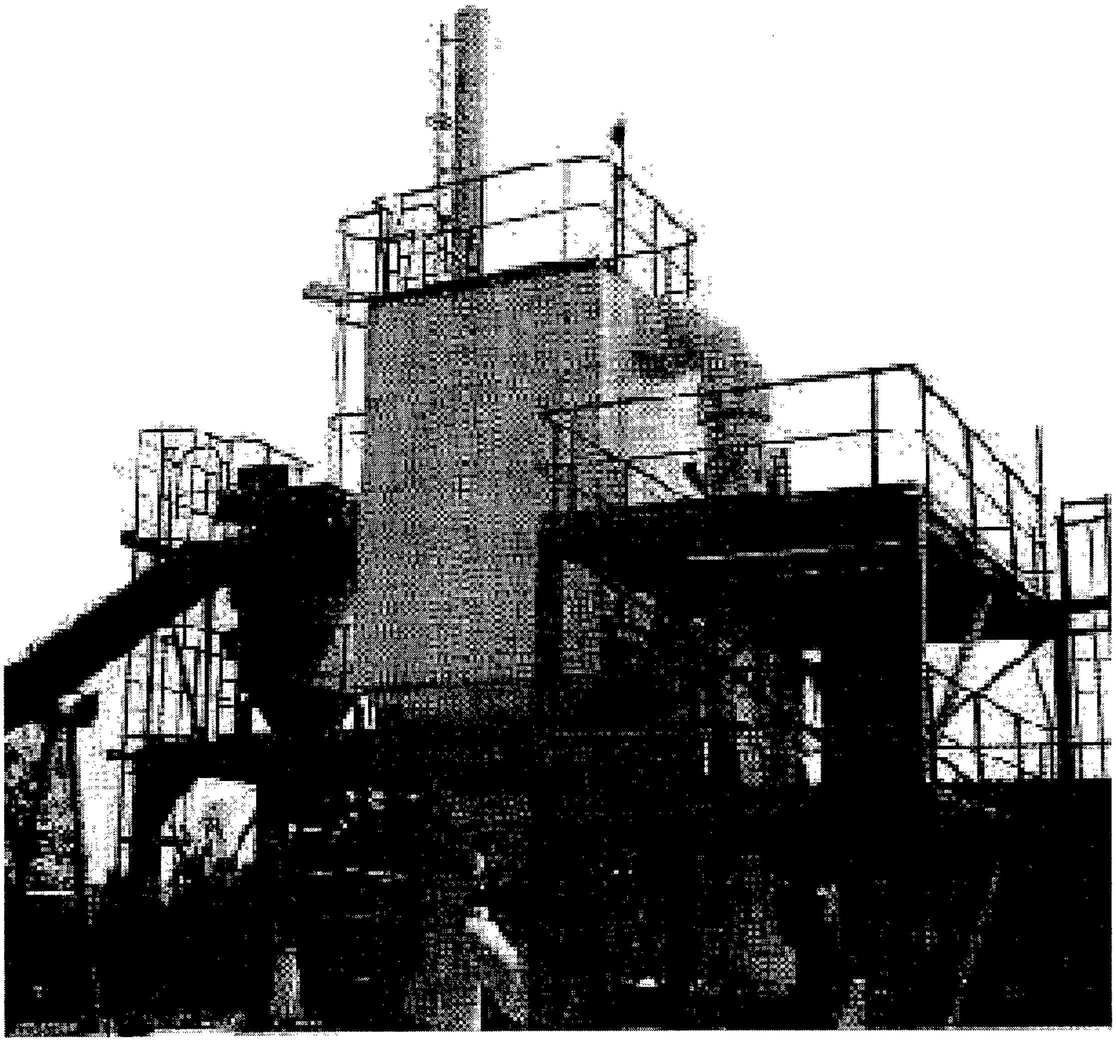


Figure 6: Disposal Facility (Waste Gas Purification) - Silberhütte



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Maintenance management
Explosives
Conversion
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Unexploded ammunition
Waste disposal
Radioactive wastes
Polychlorinated biphenyls (PCBs)
Sediments
Coatings
Paint removers
Aircraft finishes
Paints
Antifouling coatings
VOC (Volatile Organic Compounds)
Risk
Risk assessment
Cost analysis
Weapon systems
CARC (Chemical Agent Resistant Coating)
Remote sensing
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Hazardous materials
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14. Abstract

Military operations within the framework of Environmental Security are largely dependent on conformance with national and international laws or agreements to protect the air, water and ground resources. Pollution must be controlled, modified, or eliminated at the source. Society is paying a very high price today to restore and reclaim resources that have been subjected to wanton pollution for many years by both military and civilian users. Many NATO and Partnership for Peace operations and training exercises are now being constrained by national and international environmental laws. Military forces, air, land and sea, must be enabled to operate and train under a wide variety of conditions. Serious consideration must be given to compliance with the body of environmental law either in existence or now being written. Pollution Prevention activities will ensure the ability to continue operations without undue penalty or restriction.

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